THE LOWER TRIASSIC FORMATIONS OF THE SALT RANGE AND TRANS-INDUS RANGES, WEST PAKISTAN

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INTRODUCTION

The Triassic formations in the Salt Range of West Pakistan have played a particularly important role in the development of our Triassic zonal scheme, especially for the Scythian stage. In addition, interest in these formations is heightened because they conformably overlie late Permian formations, and the Triassic formations in the Salt Range have occupied the attention of nearly every student of the causes of abrupt faunal breaks. This great interest has not been matched by many modern detailed stratigraphic or paleontologic studies of these Permo-Triassic formations.

Waagen's (1895) great monograph on the "Fossils of the Ceratite Formation" was the first large scale report on a Triassic fauna from the eastern region of Tethys. In the same year Mojsisovics, Waagen, and Diener (1895) published their proposal for a classification of the Triassic System. In that paper the name Scythian was introduced for the lower series of the Triassic and the Salt Range sequence of zones presented as the type section. Later, Noetling (1901) reaffirmed the pre-eminent importance of the Salt Range sequence in Scythian chronology, at the same time modifying somewhat the scheme of zones proposed by Waagen. It was not until 30 years later that it was generally recognized that the Triassic fossil-bearing formations in the Salt Range studied by Wynne (1878), Waagen (1895), and Noetling (1901, 1905) encompassed only the lower half or so of the Scythian. Waagen's Salt Range ammonites, however, have continued to play a dominant role in our interpretation of the evolution and systematics of Scythian ammonoids.

Five months of the winter of 1961–1962 were spent in the Salt Range, studying the Triassic formations throughout the Salt Range and in the Trans-Indus ranges (Figs. 1, 2). During much of this period and on occasional short subsequent visits, Dr. Curt Teichert was occupied with a study of the Permian formations. A study of the Permo-Triassic boundary beds was undertaken as a joint project between Teichert and myself.

Teichert (1966) has presented the results of his study of the Permian "Productus limestone" of the Salt Range. The present report deals with the Triassic formations of the Salt Range and Surghar Range. The paleontological portion of this paper is restricted to new faunas from the upper part of the marine portion of the Triassic formations. Complete restudy of the faunas first described by Waagen (1895) is in progress; however, the numbers of species and specimens are very large, and further time is needed to complete this portion of the study. The fauna described here establishes a late Scythian age for the upper part of the "Ceratite Formation" of Waagen.

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HISTORY OF RESEARCH

The first serious study of the succession of strata in the Salt Range of West Pakistan was carried out by Andrew Fleming in the middle of the 19th century. One of the more important aspects of Fleming's work in the Salt Range was the collection of a suite of fossils. These were sent to England and were studied and described by such contemporary celebrities as Sir Roderick Murchison and Thomas Davidson in England, E. de Verneuil in France, and L. de Koninck in Belgium. It was the suite of fossils studied by de Koninck (1863) that provided the first indication of the "Secondary formations" in the Salt Range. The circumstances can best be related in de Koninck's (1863, p. 1) own words:

> "Among these fossils, certain species belong to genera that have hitherto only been found in the Secondary formations, and occur principally in the lower groups of that great geological period. Such, above all, are the *Ceratites*, which appear to be tolerably abundant in a rock of the Punjaub Salt-range, and are remarkable from the fact that they are all new to science. But for this last circumstance, one might have entertained serious doubts relative to their geological position, although Dr. Fleming had ascertained by personal examination that they occurred in the same beds as those which contained the Carboniferous *Producti* and *Spirifirae*. At all events there is still this remark to make, that the rock which contains the *Ceratites* has not shown me (at least in relation to the specimens confided to my examination) any traces of those other Palaeozoic genera. It is therefore to be desired that new observations should be brought to confirm those already made by the learned Edinburgh Doctor, who was the first to throw some light on the geological constitution of the ancient kingdom of Runjeet Sing."

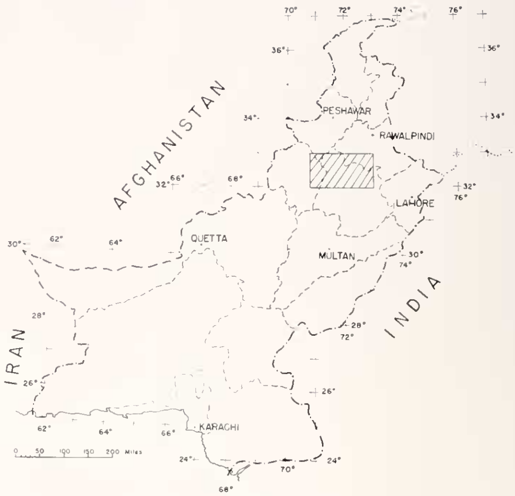

Figure 1. Map of West Pakistan showing location of area studied for this report.

The first comprehensive report on the geology of the Salt Range was by A. B. Wynne (1878) of the Geological Survey of India. Wynne carried out his field studies of the Salt Range and Surghar Range between 1869–1872. During the later stages of his study, after he had completed his mapping, he was joined by W. Waagen, who, with Wynne, made further stratigraphic observations and collected additional faunas. Wynne's (1878) report contains the only detailed account of their stratigraphic observations. It has been extremely difficult for later Triassic students to interpret Wynne and Waagen's stratigraphy and to understand the spatial distribution of Waagen's ammonites. Because these strata and their faunas have such an important bearing on our understanding of this part of the Trias-

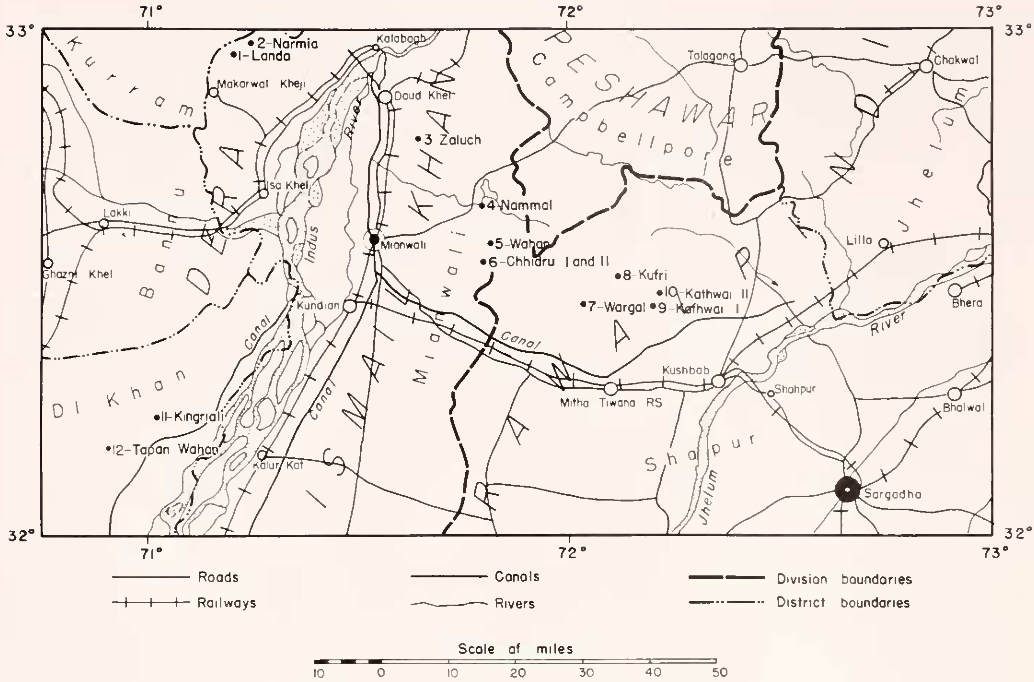

Figure 2. Map of part of the Salt Range and Trans-Indus Ranges of West Pakistan showing localities of the stratigraphic sections.

sic column, it is necessary to review in detail the Wynne-Waagen data so that the stratigraphic and paleontological data published to date can finally be clearly understood (Fig. 3).

These authors observed that the Triassic strata make their appearance around Kathwai in the central Salt Range, and from there westward to the Trans-Indus ranges these strata are amply developed and thickened. In the region of Kathwai, Wynne and Waagen measured the following section (Wynne, 1878, p. 218):

		Feet
	Greenish and gray shales, variegated, red, yellow and blue at top; *Ceratites*	20–30
Trias	*Ceratite* limestone	3–4
	Yellow, sandy calcareous beds with *Rhynchonellae*	5
———		
	Brown dolomite, like that at Pail	3
Carboniferous	Gray and greenish calcareous and micaceous sandstone, with limestone bands, weathering red in parts and containing *Bellerophon, Productus,* etc.	90–100

Approximately six miles west of Kathwai in the vicinity of Jalar (Jalhar) Waagen measured the following section (Wynne, 1878, p. 224):

		Feet
	Hard limestones with Bivalves (overlain by "Hematite," marls and limestone beds Waagen assigned to the Nummulitic).	4–5
	Thin-bedded hard limestone with different species of *Ceratites*	10
Trias	Brown sandstone with *Ceratites Flemingi*	10
	Brownish and light yellow sandstone with few *Ceratites.* In the upper part of these sandstones is the *Bel-*	

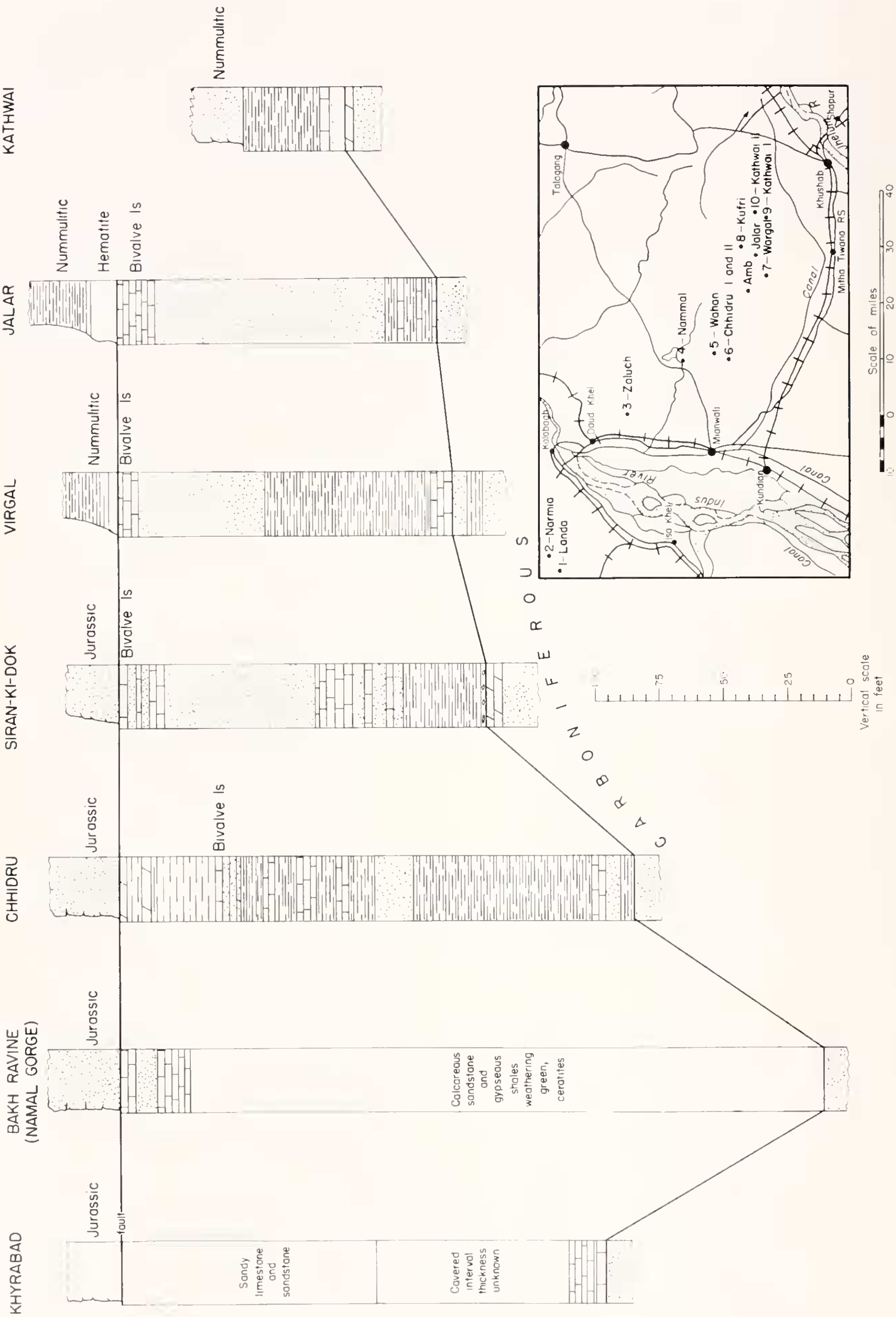

Figure 3. Diagrammatic representation of the sections of Triassic strata measured by Wynne (1878) and Waagen in the Salt Range of West Pakistan.

		Feet
	lerophon bed of this *Ceratite* group.	80
	Ceratite marl and hard thin *Ceratite* limestones	20
Carboniferous	Brown sandstones and sandy limestones of the *Bellerophon* group, very thick	100–150

Approximately four miles to the south and slightly west of Jalar, Waagen (*in* Wynne, 1878, p. 225) recorded the following sequence assigned to the Trias exposed near the village of Virgal (Wargal):

		Feet
Trias	Grey limestone with numerous Bivalves (overlain by sandstone beds assigned by Waagen to the Jurassic).	2
	Thin-bedded hard sandy limestone, no fossils	6
	Ceratite sandstone, thin-bedded, soft yellow sandstone with gypsum; a *Bellerophon* bed in the upper region.	50
	Green *Ceratite* marls	60–70
	Thin-bedded limestone with *Ceratites*	8
Carboniferous	Grey sandstone layers	6
	Black coaly, shaly beds, micaceous	3–6
	Thick light grey concretionary sandstone with nests of fossils, small *Producti*, *Bellerophon*, and *Gastropoda*	6

Near the village of Amb, Wynne and Waagen measured a thick stratigraphic sequence from the Speckled sandstone through the Nummulitic formations. They assigned 160 feet of this sequence to the Triassic recognizing a Lower Ceratite limestone and a Ceratite marls unit, combined the upper part into a limestone and sandstone unit but gave no details as to the relative thickness of their divisions (Wynne, 1878, p. 238).

High up in the Amb valley near a village of Seran-ki-dok (a locality not located by the writer nor known to the natives at the present time), Wynne and Waagen measured the following fairly detailed sequence of the Triassic (Wynne, 1878, p. 243):

		Feet	Inches
Trias	Very hard rusty limestone with numerous sections of *Ceratites* or *Ammonites*, gastropods and bivalves (overlain by sandstone beds assigned by Wynne and Waagen to the Jurassic).	3	0
	Soft yellow sandy beds	3	0
	Hard rusty-colored layer	1	6
	Grey cavernous sandstone	3	0
	Very hard grey limestone, glauconite, and bivalves	6	0
	Soft yellow sandstone	60	0
	Thin bed of sandstone with many indistinct bivalves	0	3
	Hard brown bed with numerous pebbles of limestone	1	6
	Grey limestone with numerous bivalves	3	0
	Thin-bedded limestone with *Ceratites*	10	0
	Sandstone and limestone with *Ceratites*	20	0
	Ceratite marl, badly seen	30	0
	Brown conglomerate bed	1	6
	Total	142	9
Carboniferous	Rusty dolomite	6	0
	Light colored sandstones, *Bellerophon*, *Athyris subtilita*, *Dentalium*, etc.		

Another fairly detailed section measured at a locality stated to be "east-by-north of Chideru," which I interpret to be Chhidru Nala, was measured by Waagen (Wynne, 1878, p. 248, 249):

		Feet
Trias	Hard rusty dolomite with a *Cardinia* and *Anoplophora* (overlain by sandstone beds Waagen considered as perhaps the base of the Jurassic)	3
	Green marls	6
	Rusty dolomite	3
	Green sandy marls, with sandy layers and gypsum	20–30
	Hard limestone with many bivalves	3
	Rusty sandstone, fucoids	3
	Grey sandstone with *Ceratites*, *Gervillia*, *Orthoceras*	3
	Rusty sandstone, with fucoids	2
	Grey marls with flaggy limestone	2
	Grey marls, nodular marls, and	

	hard limestones, with spinose *Ceratites*	50
	Ceratite sandstone, not clearly seen, with extremely large species of *C. Flemingii*	10–20
	Green Ceratite marls	60–80
	Flaggy lower Ceratite limestone	3–5
	Grey sandstone	6
	Green marls	4–5
Carboniferous	Yellow soft sandstones with concretions; filled with fossils, *Bellerophon*, *Athyris*, *Dentalium*, *Herculaneum*, etc.	

Between the latitude of Chhidru and Nammal Gorge, Wynne (1878, p. 251) recorded 300 to 350 feet of "Green shaly and flaggy limestone and sandstone beds" of Trias age. This locality Wynne states as the Bazar River valley which is the upper part of the Khaji Wahan Nala.

In and along Nammal Gorge (called Bakh Ravine by Wynne), these authors record the following sections (Wynne, 1878, p. 254, 255):

		Feet
Trias	Thin grey limestones	6
	Sandstones	8
	Thin grey limestones with *Ceratites*	13
	Calcareous sandstones and gypseous shales, weathering green, *Ceratites*	250
	Total	277
Carboniferous	Thin-bedded limestones and shales, sandy limestones, thick-bedded black and dark-colored limestones with a few shales, *Goniatites*, *Orthoceras*, *Spirifer*, *Productus*, *Fenestella*, *Terebratula*, Crinoids, etc.	250–300

Between Nammal Gorge and the Indus River, Wynne (1878) noted a number of Trias exposures but described them only in terms of the vaguest generalities. At Khyrabad, just east of the Indus River, Waagen measured the following sequence of Trias strata (Wynne, 1878, p. 263):

		Feet
Trias	Very hard, brown sandy limestone and sandstone (overlain by sandstone of possible Jurassic age in fault contact, according to Waagen)	100
	Space covered by debris	
	Glauconitic limestone with *Ceratites*	6–10
	Sandy marly bed	1
	Thin-bedded brown limestone, with *Rhynchonellae* and *Ceratites*	3
Carboniferous	Grey sandstone, with *Bellerophon* and *Dentalium*, badly seen.	

Wynne's report on the ranges to the west of the Indus River, including among others the Surghar and Khisor ranges, was not published until 1880. This report contains little detailed stratigraphic data regarding the Triassic formations. Wynne's general conclusions on these strata can be best summarized in his own words:

> "*The triassic Ceratite group*—Is as usual to the east stratigraphically simply a superior part of the carboniferous formation. It always accompanies the latter here, and it shows the same characteristic thin-bedded gray limestone and greenish gray shales or clays by means of which it was first distinguished in the west Salt Range sections. Its *Ceratites* are in some places numerous, in others large, and its whole aspect is that which it presents on the other side of the Indus, without any strongly marked line of stratigraphic demarkation separating it from the paleozoic beds" (Wynne, 1880, p. 240–241).

The data from the Trans-Indus ranges in Wynne's report are too incomplete to incorporate on a stratigraphic profile; however, the data for the Salt Range are diagrammed on Figure 3. In view of Waagen's subsequent writings on these Triassic strata it is of interest to note the vagueness of the lithofacies units he later recognized and the absence of reference to the Triassic strata above the Bivalve limestone to which he later referred.

Waagen's own descriptions of the rock formations exposed in the Salt Range did not appear until 1889, when he published the geological results to his monograph on Salt Range fossils. For the Triassic formations he introduced a three part division. His descriptions and comments of these units can now be understood and are quoted here (Waagen, 1889, p. 49, 50):

"Ceratite Beds

"It is somewhat doubtful whether these beds can rightly be considered as a single group, as petrographically they are always composed of three different divisions. At the base there are thin-bedded hard light-grey limestones, then follow greyish-green thick marls with some limestone beds full of fossils, and at last there comes a thick yellow sandstone with large ceratites. The distribution of these three divisions is not absolutely identical; the hard lower limestones make their first appearance in the country east of Khoora, the marls near Katruhee, and the sandstones near Jalar. On the whole, however, these beds are so intimately connected that it will be best to treat them as a whole under a common name.

"After they have made their appearance, the development of these ceratite beds is very uniform all over the Salt-range, and somewhat different sections are only to be met with in the north, in the Tredian hills. The dislocations in this country are, however, so enormous that it remains doubtful whether the differences there are not solely caused by parts of the sections being concealed by faults.

"The ceratite beds are always in perfect concordance with the underlying strata, so that, according to Mr. Wynne, they form stratigraphically a group perfectly inseparable from the Upper Productus limestone, and exhibiting a marked difference from the latter solely by their fossil contents. I perfectly concur in this respect with Mr. Wynne.

"Grey Bivalve Limestone

"The thickness of this group is nearly always very insignificant, but as it contains an apparently rather singular fauna, it seemed to me practicable to distinguish it on palaeontological grounds. It is generally composed of hard grey limestones, with countless remains of bivalve shells, which can, however, only at a few places be removed from the rock. The first place where this group has been observed by me was near Jalar. From this place towards the west the group is everywhere present, though not conspicuous. It rests everywhere conformably upon the ceratite sandstones of the preceding group, and can most easily be distinguished. Trans-Indus, its existence has not yet been proved, but it is probable that it will be also here represented.

"Grey and Yellow Dolomites

"It is only quite in the western districts that this group has been observed. The first traces of it have been found by me in the country around Chidroo, where, however, its thickness is as yet not more than 20 to 30 feet. In the Tredian hills its thickness is somewhat more considerable. It is chiefly composed of grey or rusty or yellow dolomites, with some green sandy marls. To these are added some variegated sandstones in the Trans-Indus extension of the Salt-range, where the group attains its greatest development up to a thickness of 250 feet and more.

"Everywhere I have observed the group, it rests conformably on the Bivalve limestones. Fossils are always scarce, and only some bivalves, gasteropods and a single ceratite have been found up to the present."

Waagen offered no discussions on the age of his units, but on a table (Waagen, 1889, p. 57) he placed the Ceratite beds in the Lower Triassic with question, the grey bivalve limestone in the Middle Triassic with question, and the grey and yellow dolomites in the Upper Triassic with question.

Waagen's next contribution on the Salt Range Triassic formations appeared in 1892, one version published in Vienna in German, and a modified translation in English by the Geological Survey of India. In these papers Waagen first divided the Ceratite Formation, into Lower Ceratite limestone, Ceratite marls, Ceratite sandstone, and Upper Ceratite limestone. For the uppermost unit, which he previously called the grey and yellow dolomites, he introduced the name Dolomite group, designating the upper part of this unit as the "Topmost limestone." Likewise in these publications Waagen offered more data on age assignments of these beds. He (1892b) recognized five faunal units in the interval from the Lower Ceratite limestone through the Ceratite sandstone. He felt that the difference in faunas between the Ceratite sandstone and the Upper Ceratite limestone reflected a significant stratigraphic boundary. All the units below this boundary were thus considered as equivalent to the Bunter sandstone of Europe. Waagen was not explicit as to why he came to this conclusion. It would appear that this age determination was derived from his conclusion that the Upper Ceratite limestone, and the Bivalve limestone were equivalent to the Muschelkalk of Europe. Again it is not at all apparent on what basis Waagen arrived at that conclusion. The age of the Dolomite group was decided on the basis of a single ammonite specimen which Waagen considered as "so nearly related to the genus *Tropites*" and gave the name *Pseudharpoceras*. The recognition of this specimen as a tropitid led Waagen to conclude that the Dolomite group was of Keuper age. He specifically excludes a Rhaetic age for any part of this unit, believing this to be represented within the overlying Variegated Series. This particular specimen will be discussed in detail later in this paper, but it should be pointed out that it was collected by Dr. Verchere from a yellow limestone "placed at the base of the Variegated (Jura-Rhaetic) Series at the limit of the Ceratite Formation" in the Sheik-Budin Hills of the Trans-Indus region. It is the only ammonite described by Waagen from the Dolomite group. Considerable doubt has been expressed as to the horizon of this specimen.

In his monograph on the "Fossils of the Ceratite Formation," Waagen (1895) again described the stratigraphic units of the Triassic formations and used the following nomenclature:

Dolomite Group	Topmost limestone	
	Dolomite beds	
Bivalve Limestones	Bivalve beds	
	Upper Ceratite limestone	
Ceratite Beds	Ceratite sandstone	*Flemingites flemingi* beds
		Stachella (*Bellerophon*) beds
		Lower sandstone beds
	Ceratite marls	
	Lower Ceratite limestone	

In this treatment of the Triassic formations Waagen used specific names for the three lithofacies units of the Ceratite beds, separated out the Upper Ceratite limestone and recognized two vague divisions in his upper dolomite unit. A very strange aspect of the 1895 monograph by Waagen is an absence of any discussion of the age and correlation of the Salt Range fauna from the Ceratite Formation. In the introductory pages of this monograph Waagen is evasive on the matter of age and correlation but does imply that these questions were to be discussed in a chapter on "geological results," a chapter which has never been published. A discussion of the zonal divisions and correlations of the Salt Range Ceratite Formation appeared in the same year in the classic paper by Mojsisovics, Waagen, and Diener (1895); this contained their proposal for a stratigraphic classification of the Triassic. Waagen and Diener prepared the section on the lower half of the Triassic and their scheme of classification is given in Table 1.

Waagen and Diener introduced the name Scythian in this paper. They recognized seven zones within the Scythian and used the Salt Range sequence of the Ceratite beds as the type section because it included six of the seven zones. The only zone absent in the Salt Range, that of *Otoceras woodwardi*, was known to them from the Himalayas. Under this scheme of classification one zone was recognized as encompassing the Lower Ceratite limestone, two the Ceratite marls, and three the Ceratite sandstone.

The Upper Ceratite limestone was assigned a zone unto itself, that of *Stephanites superbus*. Waagen was greatly impressed

TABLE 1. ZONAL SCHEME FOR THE LOWER HALF OF THE TRIASSIC SYSTEM FOR THE TETHYAN REALM SUGGESTED BY MOJSISOVICS, WAAGEN, AND DIENER (1895)

Series	Stage	Substage	Mediterranean Trias Province: Zone Tethyan facies	Mediterranean Trias Province: Formations	Indian Trias Province: Zone Tethyan facies	Indian Trias Province: Formations	
Dinarian	Anisian	Bosnian	Zone of *Ceratites trinodosus*	U. Muschelkalk	Zone of *Ptychites rugifer*	Muschelkalk of the Himalayas	
		Balatonian	Zone of *Ceratites binodosus*	L. Muschelkalk	Zone of *Sibirites prahlada*	Beds with *Rhynchonella griesbachi* in the Himalayas	
	Hydaspian				8. Zone of *Stephanites superbus*	Upper Ceratite limestone, Salt Range	
Scythian	Jakutian		Zone of *Tirolites cassianus*	Werfen Beds	7. Zone of *Flemingites flemingianus*	Ceratite sandstone, Salt Range	Subrobustus beds, Himalayas
					6. Zone of *Flemingites radiatus*		
					5. Zone of *Ceratites normalis*		
	Brahmanian	Gandarian		Eastern Alps	4. Zone of *Proptychites trilobatus*	Ceratite marls, Salt Range	
					3. Zone of *Proptychites lawrencianus*		
					2. Zone of *Gyronites frequens*	Lower Ceratite limestone, Salt Range	
		Gangetian			1. Zone of *Otoceras woodwardi*	Otoceras beds, Himalayas	

by the dominance of trachyostracan ammonites in the Upper Ceratite limestone and reiterated the thought that the first significant break in the sequence of the Ceratite Formation came between that unit and the underlying Ceratite sandstone. No mention was made in this report of the age of the Dolomite Group.

Waagen's work on the stratigraphy and paleontology of the Ceratite beds was subjected to a series of highly critical attacks by Fritz Noetling. This author states (Noetling, 1901, p. 370) that he spent the winter of 1893–94, November, 1898, and finally the winter of 1899–1900 in the Salt Range. At first, Noetling (1900a) maintained that the Ceratite Formation must be included in the Permian System because the gradual passage from the Productus limestone to the Ceratite beds made assignment of these units to two different eras impossible. In addition, he reported the presence of *Otoceras* from the Ceratite marls, which he then correlated with the Himalayan *Otoceras* beds, and assigned a Permian age to all these beds (Noetling, 1900b).

The identification of *Otoceras* in the Salt Range was soon retracted. Griesbach, the discoverer of the *Otoceras* fauna in the Himalayas, assigned the fauna to the Lower Triassic (Griesbach, 1880). Also, Mojsisovics (1892 a, b) came to the conclusion that it is "most probable" that the *Otoceras* beds formed the base of the "Bundsandstein" and are closest to the boundary of the Permian.

Noetling received support in his views on the stratigraphic position of *Otoceras* from A. v. Krafft (1900, p. 203), who, in a preliminary report on the stratigraphy of the Spiti region, correlated the *Otoceras* beds there with the Ceratite marls and the Lower Ceratite limestone of the Salt Range. In the following year, Krafft (1901) changed his interpretation considerably. He divided the strata exposed between the Kuling shale and the *Hedenstroemia* beds in the Spiti region into three zones: the *Otoceras* bed, the *Ophiceras* bed, and the *Meekoceras* bed. The *Meekoceras* bed he referred to the Triassic, the age of the *Ophiceras* bed was left in doubt, and the *Otoceras* bed was correlated with the Upper Productus limestone on the strength of the identification of *Medlicottia* (*Episageceras*) *dalailamae* Diener with *Medlicottia wynnei* Waagen from the zone of *Euphemus indicus* in the Salt Range. Diener (1901b) refuted this argument, rejecting the identity of these two species of *Medlicottia* (*Episageceras*).

In 1901, Noetling published a long paper on the Permian and Triassic formations of the Salt Range, in which he presented stratigraphic data on the section at Chhidru and Virgal (Wargal) and introduced a zonal scheme. Noetling's Chhidru section is along the east side of the nala at a site called Mittiwali (Noetling called it Mittiali), a section also studied by the author; Noetling's description of this section is as follows (the numbers are in Noetling's original section and only part of the Upper Permian strata are included):

	Thickness Feet	Inches
26. Sandstone, white, sandy	26	0
25. Sandstone with *Stachella*	5	0
24. Limestone, olive, thin-bedded, platty, hard, with thin shale interbeds. Contains numerous examples of *Stephanites superbus* Waagen, *Prionites tuberculatus* Waagen, *Acrochordiceras distractus* Waagen	50	0
23. Sandstone, olive, brownish, hard, containing numerous specimens of *Flemingites flemingianus* Waagen, *Hedenstroemia* spec. (new), *Aspidites superbus* Waagen	10	0
22. Marl, dark green, thin-bedded, thin beds of limestone, fossiliferous, containing *Koninckites volutus* Waagen, *Prionolobus rotundatus* Waagen, *Celtites* spec. and many other species	100	0
21. Limestone, dark brown, hard, flaggy, with numerous poorly preserved fragments of ceratitic ammonites	3	0
20. Marl, green, unfossiliferous	2	0
19. Limestone, dark brown, hard, flaggy, with numerous poorly preserved ceratitic ammonites	5	0

18. Sandstone, light brown, calcareous, thin-bedded, with argillaceous layers	2	6
17. Limestone, rusty brown, hard, ringing under hammer, with indistinct traces of ammonites	0	4
16. Sandstone, light brown, with argillaceous interbeds	3	0
15. Sandstone, dark, hard, full of fossil fragments, probably *Bellerophon* or *Stachella*	0	6

Noetling (1901, p. 453) stressed the conformity of these strata and concluded, after an extensive discussion, that the Permian-Triassic boundary lay between beds 16 and 17.

Noetling's (1901, p. 454) Virgal (now Wargal) section is really too generalized to be of much help. He records 18 feet of Lower Ceratite limestone overlain by 120 feet of marls which are presumably part of the Ceratite marls.

It appears that Noetling's views on the Triassic formations of the Salt Range were formulated mainly from his studies at Chhidru and Virgal (Wargal). In terms of the stratigraphic divisions recognized by Waagen (1895), Noetling concluded that the Dolomite Group was not Scythian in age (a view never held by Waagen); that the Ceratite sandstone of Waagen was merely a sandy facies of the Upper Ceratite limestone; that the Bivalve beds of Waagen in general did not exist. He (Noetling, 1901) then introduced the following zonal scheme (Table 2). (His zones for the Upper Permian Chhidru Group are included, as they have bearing on correlation problems of these strata.)

This scheme represented a considerable revision of Noetling's previous views, a fact commented upon by Diener (1901a). Noetling considered this zonal scheme to represent "die Gliederung der Skythischen Stufe von oben nach unten." In the single zone for the Upper Ceratite limestone he was in agreement with Waagen, but for the Ceratite sandstone he considered one zone as representative rather than the three recognized by Waagen. He was influenced in this conclusion by the following observations: (1) *Stachella* was not confined to the mid part of the Ceratite sandstone but was also present in the Ceratite marls and the Upper Ceratite limestone; (2) *Ceratites normalis* (the zonal index for the lower part of the Ceratite sandstone according to Waagen) was established for a poorly preserved fragmentary specimen that could not be identified; and (3) *Flemingites radiatus* (the zonal index for the middle part of the Ceratite sandstone, the horizon of *Stachella* according to Waagen) was nothing more than the inner whorls of *Flemingites flemingianus*. The substitution of two different zonal index species for the Ceratite marls was based on his objection to the poor state of preservation of Waagen's species. According to Noetling, the zone of *Koninckites volutus* encompassed the greater part of the Ceratite marls, and the zone of *Prionolobus rotundatus* was confined to the basal beds of the unit. For the Lower Ceratite limestone, Noetling objected to Waagen's narrow conception of the genus *Gyronites* and its separation from *Xenodiscus*.

In this same 1901 paper, Noetling correlated his zone of *Flemingites flemingianus* and the zone of *Koninckites volutus* with the *Hedenstroemia* beds of the Himalayas, and the zone of *Prionolobus rotundatus* and the zone of *Celtites* sp. with the zone of *Meekoceras lilangense* of the Himalayas. He then considered the two uppermost zones of his Chideru (Chhidru) Group (that of *Euphemus indicus* and *Medlicottia wynnei*) as correlative with the *Ophiceras tibeticum* Zone of the Himalayas, and the zone of *Bellerophon impressus* as equivalent to the *Otoceras woodwardi* Zone of the Himalayas. It is of interest to note that in this same paper Noetling (1901) offered as an explanation for the extinction of the Permian brachiopod fauna the change from deeper water conditions in the Permian to shallower water in the Triassic; the deep water brachiopods died out and were re-

TABLE 2. ZONAL SCHEME FOR UPPER PERMIAN AND LOWER TRIASSIC FORMATIONS OF THE SALT RANGE, WEST PAKISTAN, AFTER NOETLING (1901)

Scythian	Upper Ceratite limestone	Zone of *Stephanites superbus*
	Ceratite sandstone	Zone of *Flemingites flemingianus*
	Ceratite marls	Zone of *Koninckites volutus* Zone of *Prionolobus rotundus*
	Lower Ceratite limestone	Zone of *Celtites* (?) sp.
Thuringian Stage	Chideru Groups (now Chhidru)	Zone of *Euphemus indicus* Zone of *Medlicottia wynnei* Zone of *Bellerophon impressus* Zone of *Cyclolobus oldhami* Zone of *Derbyia himisphaerica* Zone of *Productus lineatus*

placed by ammonites, which preferred near-shore water conditions.

Noetling's last contribution on the Salt Range, which appeared in the Lethaea Geognostica (1905), repeated the stratigraphic data given in 1901, but he made some additions to his previous interpretations. First, he accepted the Ceratite sandstone as a lithostratigraphic unit of independent status. For the zone of the Lower Ceratite limestone, he introduced the name of *Celtites radiosus* (Koken manuscript) Frech, and he introduced a new zone, that of *Celtites fallax* (Koken manuscript) Frech, encompassing the middle part of the Ceratite marls. Noetling likewise maintained that the sequence of Permian and Triassic strata in the Salt Range represented continuous deposition. At this time he suggested that an increase in the temperature of the sea was responsible for the extinction of the brachiopods. In fact, to explain the absence of brachiopods in the *Otoceras* beds of the Himalayas (which he considered Permian in age), Noetling suggested that the change in temperature progressed from the north to the south, thus affecting first the Himalayan region, while the brachiopods persisted in the Salt Range.

In the early 1930's E. R. Gee mapped the entire Salt Range on the scale of 2 miles to 1 inch. His maps have not yet been published, but are available for study and inspection in the archives of the Geological Survey of Pakistan in Quetta. In the intervening period, between the time of Noetling's publications and Gee's mapping, the only significant writing on the Triassic Formation of the Salt Range was offered by Diener (1912), who gave a splendid review of the boundary problem and the age of *Otoceras*.

Although Gee's maps of the Salt Range remain, as yet, unpublished, he did publish occasional observations. In one of these, Gee (1947, pp. 143–147) presented a detailed description of the stratigraphic section in Nammal Gorge (Bakh ravine of Wynne's report); the Triassic formations there are described as follows:

	Feet
Trias (?) 361–366 feet	
Kingriali Dolomites (186–188 feet)	
(e) Hard, dark grey, splintery limestone	14
(d) Light grey and yellowish, massive, fine-textured, hard splintery limestones, and dolomitic limestone weathering vesicular near the base. Some fossils visible but difficult to extract	147
(c) Sandy, red, ferruginous band	1
(b) Yellow-grey, falsebedded, calcareous sandstone	14
(a) Yellow brown, hard, bedded limestone	11–12
Kingriali Sandstones (238–242 feet)	
(f) Grey and greenish sandy shales	4–5

(e) Hard, dark-brown, calcareous sandstone and impure limestones	1–3
(d) Massive grey and yellowish medium-textured sandstone with 3 to 4 feet carbonaceous shale band in the middle	115
(c) Grey and ferruginous, purplish-brown, ripple-marked sandstones alternating with purplish-brown shales and micaceous flags with plant fragments, the shales predominate in the lower part	55
(b) Hard, fine-textured, greenish-grey weathering russet-brown limestone	3–4
(a) Grey and greenish-grey shales alternating with brownish-weathering limestones and sandstones	50
Hard grey and brownish limestone	10
(comformable transitional junction)	
Trias (343–345 feet)	
Ceratite Beds	
(f) Grey and purplish, calcareous sandstones, flags and shales alternating, about one half is shale	64
(e) Grey and greenish grey shales with flaggy grey-green sandstone bands	42
(d) Grey and brownish-grey bedded limestone with shale bands, and including numerous badly preserved fossils	5
(c) Grey-green shales with flaggy, grey, *Ceratite*-bearing limestones alternating; limestones prominent in lower half	51
(b) Dull green and flaggy sandstone shales with a few limestone bands, shales predominate	117
(a) Flaggy, grey, *Ceratite* limestone	4–6
(Base of Trias apparently conformable to Upper Productus beds, top of the latter is weathered russet-brown)	
Permian	
Productus Limestones (703–723 feet)	
Upper Productus beds (226 feet)	
(c) Brownish-grey, weathering russet-colored, hard arenaceous limestone	6
(b) Soft grey sandy shale	2.5–3

Additional observations by Gee on the Triassic formations of the Salt Range were published by Pascoe (1959). In this report the name Mianwali series was introduced to include the three units recognized by Gee in 1947, namely the Ceratite beds, Kingriali Sandstones, and the Kingriali Dolomites.

Schindewolf (1954) studied the Permian-Triassic contact beds on the west side of Chhidru Nala and presented a measured section of the boundary strata essentially the same as that by Kummel and Teichert. Schindewolf's most important contribution to knowledge of the Triassic System was the discovery of *Ophiceras connectens* in beds below the Lower Ceratite limestone.

PRESENT INVESTIGATION

The adoption of a modern stratigraphic code by the Geological Survey of Pakistan as a guide for future geologic studies in Pakistan has required the introduction of a modern nomenclature for the Triassic formations of the Salt Range and Trans-Indus ranges. A modern nomenclature for some of the Permian and Triassic formations of the Salt Range has been introduced by Kummel and Teichert (1966 a, b) and is shown here on Table 3.

In the course of my own studies, seven sections of Triassic rocks were studied in detail (Fig. 4). These range from one at Kathwai in the most eastern outcrop area of the Triassic formations in the Salt Range to Landa Nala and Narmia Nala in the Surghar Range west of the Indus River. Attention was focused mainly on the Mianwali Formation which includes most of the strata formerly referred to as the Ceratite beds. Of the Tredian Formation detailed study was made only of the Landa Member. The Khatkiara Member has been studied by Danilchik and Shah (in press) and the Kingriali Dolomite by Gee (1947).

The detailed measured sections of the Triassic formations for the seven localities studied comprise Appendix I. A diagrammatic representation of these sections is shown on Figure 4 and a schematic facies interpretation is shown on Figure 5.

MIANWALI FORMATION

The name Mianwali was first used by Gee (*in* Pascoe, 1959, p. 852) in a time

TABLE 3. PERMIAN AND TRIASSIC FORMATIONS IN THE KHISOR RANGE, SURGHAR RANGE, AND SALT RANGE, WEST PAKISTAN

System	Series	Stage	Formation		Old Name
TRIASSIC	Upper?		Kingriali Dolomite (Gee, 1947)		Kingriali Dolomite (Gee, 1947)
	Middle?		Tredian Fm.[4]	Khatkiara Member[3]	Kingriali Sandstones (Gee, 1947)
				Landa Member[2]	
	Lower	Scythian	Mianwali Fm.[2]	Narmia Member[2]	Topmost ls. Dolomite beds (Waagen, 1895)
				Mittiwali Member[2]	Bivalve ls. (Waagen, 1895)
				Kathwai Member[2]	Ceratite beds (Waagen, 1895)
PERMIAN	Upper	Chhidruan	Chhidru Formation[1]		Upper Productus limestone (Waagen, 1879)
		Guadalupian	Wargal Limestone[1]		Middle Productus limestone (Waagen, 1879)
	Lower	Artinskian	Amb Formation[1]		Lower Productus limestone (Waagen, 1879)

[1] Waagen, 1891; emend. Noetling, 1901, and Teichert (in press).
[2] Kummel (in press).
[3] Danilchik and Shah (in press).
[4] Gee (in press).

stratigraphic sense for all rocks in the Salt Range believed to be of Triassic age. It is here proposed for a lithostratigraphic unit which is equivalent to the lower part of Gee's Mianwali series only.

The Mianwali Formation is the fossiliferous unit which has yielded all of the Triassic ammonites that have been described from the Salt Range. It comprises all the facies units (e.g. Lower Ceratite limestone through Topmost limestone) recognized by Waagen (1895). The formation represents a great wedge of varied facies, thickest in the west and thinning to the east. The thickest development of the formation studied is in Narmia Nala in the Surghar Range—635.5 feet (Fig. 4). In the easternmost areas of outcrop the formation is only 48.4 feet thick (at Kathwai), but here the section is truncated by erosion and overlain by the Dhak Pass Formation of Paleocene age. Complete development of the Mianwali

Formation is found in the Surghar Range and in the western part of the Salt Range at Zaluch and Nammal Gorge. In Chhidru Nala the upper part of the Narmia Member is truncated and overlain by the Murree Formation of Miocene age, but one mile further east the Mianwali Formation is complete, though its thickness is not known (Curt Teichert, written communication). At Kufri, the Kathwai Member and only 10 feet of the Narmia Member are preserved. From Nammal Gorge west to the Surghar Range, the Mianwali Formation is overlain conformably by the Landa Member of the Tredian Formation.

The contact of the Mianwali Formation with the underlying Chhidru Formation, of Upper Permian age, was a special project carried out in collaboration with Curt Teichert. Preliminary accounts of our studies of this extremely critical Permo-Triassic boundary have been prepared (Kummel and Teichert, in press), and no extended discussion will be given here. It is sufficient to state that we interpret the contact as a paraconformity but are not able to offer any concrete data as to the possible duration of the break in deposition in this area.

Kathwai Member

The lowest unit of the Mianwali Formation is a remarkably uniform dolomite and limestone bed present throughout the outcrop area of the Triassic formations in the Salt Range and in the Trans-Indus Ranges. Kummel and Teichert (in press) have recognized two units in the Kathwai Member, a lower dolomite unit and an upper limestone unit. The dolomite for the most part is finely crystalline with euhedral and anhedral grains. Some of the dolomite rhombs have been partly or entirely replaced by calcite. A large part of the rock unit consists of fossil fragments, mainly echinodermal, which are dolomitized, partially dolomitized or of recrystallized calcite. Fine-grained angular to subangular grains of quartz make up a small percentage of the rock, seldom as much as 10 per cent. The individual bedded units of dolomite vary from massive to finely laminated; cross-bedding is not uncommon.

The upper unit of the Kathwai Member is a gray to brown, fine-grained limestone containing abundant shell fragments and echinoderm remains. The upper part of this unit is usually glauconitic and the lower part generally transitional with the underlying dolomite unit. This limestone unit is, like the dolomite unit, remarkably uniform throughout the area studied. Only at Chhidru and Munta Nala (Wargal) were some thin laminated sandstone beds present in the upper part of the unit.

The thickness of the Kathwai Member is also remarkably uniform. It is 7.5 feet thick at Narmia, 11.5 feet at Zaluch, 11 feet at Nammal Gorge, 16.8 feet at Chhidru, 15.5 feet at Kufri, and 12.5 feet at Kathwai.

Fossils are not uncommon in the Kathwai Member but at the same time are neither abundant nor well preserved. The most significant fossil is *Ophiceras connectens* Schindewolf which occurs throughout the member. In addition, a species of *Glyptophiceras* sp. indet. was found in the dolomite unit at Kathwai. These two species clearly indicate that the Kathwai Member is of lowest Scythian (*Ophiceras* zone) age. The remainder of the fauna of the Kathwai Member includes: lagenid-type Foraminifera; *Lingula* sp., rhynchonellids; pseudomotid, pectinid and other, indeterminate, pelecypods; crinoid and ophiuroid fragments, including one identified as *Ophioderma*? cf. *torrii* Desio by Hans Hess (written communication to Curt Teichert, 1964); *Miocidaris pakistanensis* Linck (most obviously and abundantly represented by spines); conodonts as reported by Huckriede (1958)[1]; fish teeth as reported by Waagen (1895). Bobb Schaeffer has examined samples from the dolomite unit exposed on the

[1] W. C. Sweet is undertaking a monographic study of the conodonts from the Mianwali Formation; he reports (written communication) that conodonts are richly represented throughout the formation.

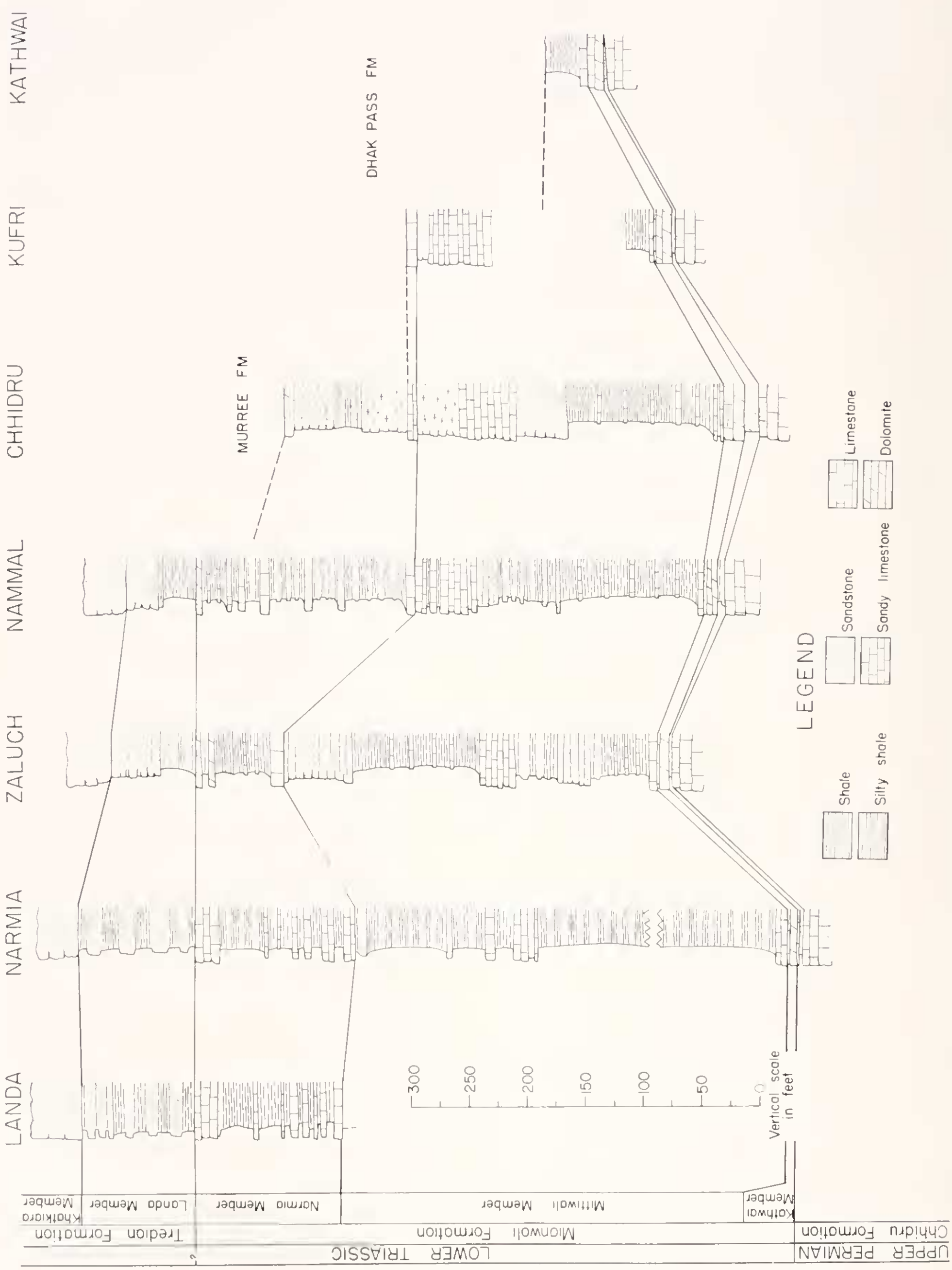

Figure 4. Stratigraphic sections of Lower and Middle? Triassic strata in the Salt Range and Surghar Range of West Pakistan.

east side of Chhidru Nala and was able to identify in these samples *Acrodus* sp., possibly one specimen of *Saurichthys* sp., but none of *Colobodus* nor *Gyrolepis* as recorded by Waagen.

The most surprising paleontological discovery from the Kathwai Member was the presence of brachiopods of genera otherwise known only from Permian rocks. In a preliminary paper (Kummel and Teichert, 1966b, in press), we have discussed these Permian brachiopods in detail. We were aided greatly in our studies by Dr. G. A. Cooper, who identified the brachiopods for us. For the present purpose I wish merely to give data on their occurrence and their interpretation. One specimen of a productid brachiopod was found on the east side of Chhidru Nala, six inches above the base of the Kathwai Member, in beds from which specimens of *Ophiceras connectens* had been found. Just west of Chhidru Nala, in Khan Zaman Nala, Teichert (personal communication) collected *Crurithyris* sp. (identified by G. A. Cooper) 5–6 feet above the base of the Kathwai Member. The largest number of these brachiopods was found in the lower 6–12 inches of the Kathwai Member in Narmia Nala. From collections made from this bed, G. A. Cooper has identified *Linoproductus* sp., *Spirigerella derbyi* Waagen, *Orthotetina* sp., *Enteletes* sp., *Martiniopsis?* sp., *Crurithyris* sp., *Lingula* sp., *Orthotichia* sp., and *Martinia* cf. *M. chideruensis* Waagen. As regards the age of these brachiopods, Cooper (written communication) writes as follows:

> "Taking all of the information and putting it together I come to the same conclusion as previously. The presence of *Enteletes*, *Crurithyris* and *Orthotichia* suggests Lower or Middle Permian and the other named shells are inconclusive. Everything listed would be expected in earlier Permian than the Upper except the *Martinia* cf. *M. chideruensis*, the identification of which I am unsure. All of the assemblages are definitely Permian and I should say rather Middle Permian than Upper in aspect."

Cooper (personal communication) feels that all of the Permian brachiopods we sent him are the product of reworking. In this I am in full agreement. However, Teichert, only with the greatest reluctance, would accept the reworking hypothesis for the main brachiopod horizon at Narmia, but rejects this entirely for the Khan Zaman occurrence where *Crurithyris* was found 5–6 feet above the base of the Kathwai Member.

Mittiwali Member

The Mittiwali Member comprises the units Waagen (1895) designated as Lower Ceratite limestone, Ceratite marl, Ceratite sandstone and Upper Ceratite limestone. This member is 487.5 feet thick in Narmia Nala, 321.6 feet at Zaluch, 253 feet at Kufri, and only 40 feet at Kathwai in the eastern extremity of Triassic outcrops in the Salt Range. At the Kathwai locality the upper part of the Triassic sequence has been truncated by pre-Cenozoic erosion and the remnants existing are overlain by Paleocene limestone.

The lowest unit of the Mittiwali Member is a coquinoid limestone to which Waagen (1895) gave the name Lower Ceratite limestone. The unit is a gray, fine-grained limestone, with no glauconite, and containing a great abundance of ammonites, generally very poorly preserved. It is this unit which most previous authors, until Schindewolf (1954), placed at the base of the Salt Range Triassic sequence. Throughout the Salt Range this basal limestone unit is about five to six feet thick. In the Khisor Range, west of the Indus River, Teichert (personal communication) measured 25 feet for this unit. It is distinguished from the underlying limestone unit of the Kathwai Member by an absence of glauconite and a much greater abundance of fossils consisting almost entirely of ammonites, with occasionally a few pelecypods. The ammonites belong to the Gyronitan age of Spath (1934), the second zone in the sequence of Scythian

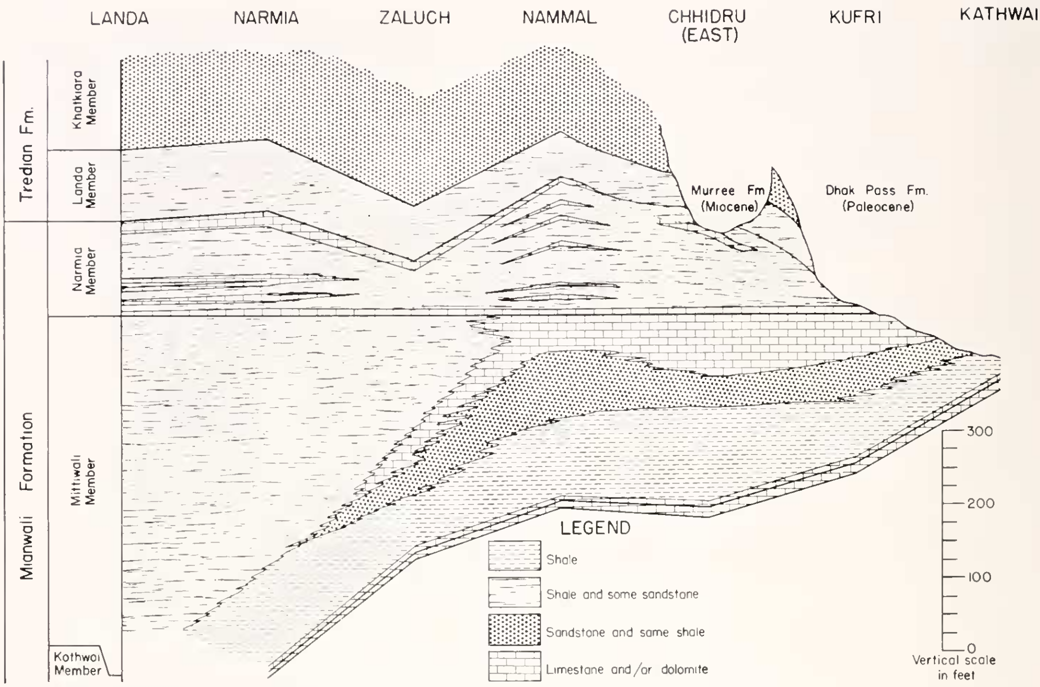

Figure 5. Diagrammatic reconstruction of facies relationships of Lower and Middle? Triassic strata in the Salt Range and Surghar Range of West Pakistan.

ammonoid zones. I have in progress an intensive revision of this fauna. Like the underlying Kathwai Member, the Lower Ceratite limestone is remarkably uniform throughout the Salt Range and the Trans-Indus Ranges.

It is in the remaining strata of the Mittiwali Member that one finds an interesting diversity in lithofacies. Waagen's sequence of the Ceratite marls, Ceratite sandstone, and the Upper Ceratite limestone is recognizable in a general way only in the central region of the Salt Range from Nammal Gorge east to Kufri. West of Nammal Gorge this portion of the Mittiwali Member becomes a fairly homogeneous sequence of shale, silty shale, with some thin sandstone and limestone beds. A diagrammatic interpretation of these east–west facies changes is shown on Figure 5.

The Ceratite marls are clay shales, greenish to gray-black in color, with fairly numerous lenticular beds (1 to 6 inches thick) of argillaceous limestone. The Ceratite marls are very fossiliferous, but the fossils are almost entirely restricted to the thin lenticular limestone beds. The fauna is completely dominated by ammonites with a few nautiloids and pelecypods. The ammonoids are being extensively revised and will not be treated here. The most common nautiloid species is *Menuthionautilus kieslingeri* Collignon; in addition, much less common species include: *Grypoceras bidorsatoides* Kummel, *Grypoceras aemulans* Kummel, and *Pleuronautilus kokeni* Frech (Kummel, 1953). Among the pelecypods, Lukas Waagen (1900, p. 286) has identified *Pecten discites* Schlotheim and *Pecten* cf. *albertii* Goldfuss. Ostracods (I. G. Sohn, written communication) and conodonts (W. Sweet, written communication) are also present.

The Ceratite marls grade upward into

the Ceratite sandstone beds. These sand beds are massive to laminated in bedding, frequently crossbedded, and have ripple marks. The laminated units generally contain numerous thin shale laminae and are usually micaceous. The Ceratite sandstone is generally friable and soft, forming low covered slopes. This unit is well exposed only in Nammal Gorge and along the east side of Chhidru Nala. At all other localities studied in this part of the Salt Range this unit was mostly covered. The Ceratite sandstone is characterized by two very conspicuous fossils: large specimens of *Flemingites* (up to two feet in diameter) and the bellerophontid *Stachella*. Waagen (1895) considered this bellerophontid to be confined to the mid-part of his Ceratite sandstone and on this basis divided the unit into three divisions and zones. There is one outcrop of the Ceratite sandstone in the upper part of Chhidru Nala where *Stachella* does occupy this position, but in another part of the Nala, where the Ceratite sandstone crops out, *Stachella* is absent. *Stachella* was likewise not found in the Ceratite sandstone exposed in Nammal Gorge, nor at any other locality. It is highly dubious that this bellerophontid has any stratigraphic significance.

As in the other members of the Mianwali Formation, ammonites dominate the fauna; comments on the ammonoids will be reserved for a later paper. Among the non-ammonoid fossils, Lukas Waagen (1900, p. 286) identified: *Pecten discites* Schlotheim var. *microtis* Bittner, *Pseudomonotis* ex aff. *telleri* Bittner, *Pleurophorus?* (*Clidophorus?*) sp., *Nucula* sp., *Macrocheilus?* sp., *Turbonilla* (*Holopella*) *gracilior* Schauroth, *Amauropsis?* sp., *Bellerophon* (*Stachella*) sp., *Rhynchonella* sp.

The Ceratite sandstone grades upward into the Upper Ceratite limestone. The unit is somewhat misnamed as limestone comprises only about 60 per cent of the unit, the remainder consisting of shale and sandstone. Eastward at Chhidru and at Kufri, sandstone and shale comprise an even larger percentage of the unit, and much of the limestone is conspicuously sandy. The limestone is gray, thin to medium bedded, fine grained, and contains abundant fragmental shell remains. The limestone beds are generally quite fossiliferous but unfortunately the preservation is, with few exceptions, very poor. Like the lower units of the Mianwali Formation, the ammonites completely dominate the fossil faunas. In addition, there are seen occasional pelecypods but little else. The ammonite fauna includes *Anasibirites*, *Prionites*, *Hemiprionites*, etc., and is undergoing complete restudy. Lukas Waagen (1900, p. 287) identified the following pelecypods from this unit: *Gervillia* cf. *exporrecta* Lepsius, *Pecten* ex aff. *ussuricus* Bittner, *Myophoria* cf. *laevigata* Alberti, *Pecten albertii* Goldfuss, *Nucula* sp.

Narmia Member

This unit comprises the strata Waagen (1895) called the Bivalve beds, Dolomite beds and the Topmost limestone. It has been the least understood part of the "Ceratite Formation." This is mainly due to the treatment of these units by Wynne and Waagen in their publications on the Salt Range.

Throughout the Salt Range and Trans-Indus Ranges the basal bed of the Narmia Member is a thin (ten feet more or less), complex limestone. At Chhidru and Kufri this basal limestone unit is the Bivalve limestone of Waagen. It is a hard, light-gray, massive limestone, mainly a coquina of pelecypods. At Chhidru this limestone bed also contains poorly preserved ammonites and nautiloids (*Enoploceras* and orthocerids) in addition to the pelecypods. In Nammal Gorge this limestone unit is seven feet thick and consists of alternating coquinoid beds, like those that make up the whole unit at Chhidru and Kufri, and irregularly bedded limestone containing poorly preserved brachiopods, ammonites, pelecypods, and gastropods. At Zaluch Nala the unit is like that at Narmia, but in addition contains some glauconite. In the Surghar Range, at Narmia and Landa, this basal limestone unit no longer is a pelecypod coquina but is a dark-gray to brown, fragmental limestone, sandy in part, containing poorly preserved pelecypods, ammonites, and brachiopods.

Much of the remainder of the Narmia Member consists of olive to gray-black shales, often with thin laminae and beds of fine sandstone interbedded with 2 to 10 foot beds of limestone. These limestone beds are highly varied in their lithologies. They are often dolomitic, glauconitic, pelletal, sandy, and occasionally have thin shale interbeds. The uppermost unit of the Narmia Member in the Surghar Range is a unique pisolite bed containing *Spiriferina* and other brachiopods and echinoid spines. The pisolite bed is 7 feet thick at Narmia and 4.5 feet thick at Landa Nala. In the Salt Range there are much fewer limestone beds in the Narmia Member, the few hard carbonate beds which do exist are either dolomitic limestone or dolomite. At Zaluch, for instance, the uppermost beds of this member are gray to brown massive dolomite. This may also be observed in Nammal Gorge. In the Salt Range at Nammal Gorge and Zaluch the non-carbonate portion of the Narmia Member contains a much higher percentage of sand relative to shale than in the Surghar Range. At Chhidru the Narmia Member, aside from the basal "Bivalve limestone" and an upper dolomite bed, consists of tan sandstone that is micaceous and shaly in part.

The Narmia Member is 128 feet thick at Landa and 140 feet at Narmia in the Surghar Range, 75 feet at Zaluch, 189 feet at Nammal Gorge, 118.5 feet at Chhidru, and only 10 feet at Kufri. At Chhidru the member is truncated by erosion and overlain by the Miocene Murree Formation. In Khan Zaman Nala, about 1 mile east of the Chhidru Nala section, the Narmia Member is again fully developed, though its thickness has not been measured (Curt Teichert, written communication). At Kufri it is overlain by Paleocene limestone. The thinness of the member at Zaluch is believed to be due to minor faulting within the sections and has no regional significance.

The limestone beds of the Narmia Member are fossiliferous but, unfortunately, fossils are neither abundant nor well preserved. The fauna includes ammonites, nautiloids, brachiopods, echinoid spines, and crinoid remains. The most important of these fossils, at least for dating the member, are the ammonites. In the systematic portions of this report 15 species of ammonites are described; Waagen (1895) had described 4 species. This ammonite fauna clearly indicates a late Scythian age for the Narmia Member.

TREDIAN FORMATION

Immediately overlying the Mianwali Formation are a series of non-marine strata about which there has been some confusion. Gee (1947) was the first to recognize these strata and proposed the name Kingriali Sandstones for them. Subsequent work has revealed that two distinct mappable units can be recognized within the Kingriali Sandstones: a lower predominantly shale unit and an upper predominantly sandstone unit. At the time he introduced the name Kingriali Sandstones, Gee (1947) also named the overlying strata the Kingriali Dolomites. Both are presumably of Triassic age, but to avoid a double usage of the name Kingriali, the name Tredian Formation (Gee, in press, in report of Stratigraphic Commission, Geological Survey of Pakistan) was introduced (See Table 3). For the lower shaly member of the Tredian Formation I have proposed the name Landa Member, and for the upper sandy member of the formation, Danilchik and Shah (in press) have proposed the name Khatkiara Member. I have not studied the Khatkiara Member, therefore only the beds assigned to the Landa Member will be discussed here.

Landa Member

The type section of this member is in Landa Nala in the Surghar Range where it is 100 feet thick. The member consists of sandstone and shale, in about equal proportions. The sandstone may be black, pink, or red, and is micaceous, thin to massively bedded, with ripple marks and slump structures. The shale is generally black, sandy and micaceous. The member is 72 feet thick in Zaluch Nala and 63 feet in Nammal Gorge. The member is not present in Chhidru Nala but is fully developed one mile to the east in Khan Zaman Nala (Curt Teichert, written communication). East of Khan Zaman Nala the member is rapidly beveled and is not present at Kufri nor Kathwai.

The only fossils observed in the Landa Member are poorly preserved and fragmentary plant remains. The samples of fossil plants and shale reported on by Sitholey (1943), Pant (1949), and Pant and Srivastava (1964), from south of Sakesar Ridge in the Salt Range, are most probably from the Landa Member.

AGE AND CORRELATION OF MIANWALI FORMATION

It has long been established that the Ceratite beds of the Salt Range are of Lower Triassic, Scythian age. In fact they were selected by Waagen and Diener (in Mojsisovics, Waagen and Diener, 1895) as the type section of the Scythian for the "pelagischen Sedimente des Trias-Systems." Waagen's early efforts to place the Upper Ceratite limestone in the Middle Triassic and to assign his Dolomite unit to the Keuper were never accepted. Noetling (1901, 1905) interpreted the fossiliferous Triassic beds of the Salt Range (through the zone of *Stephanites superbus* of the Upper Ceratite limestone) as including a complete succession of faunal zones for the Scythian. This view was held by Diener (1912, p. 256), Welter (1922, p. 92), and others.

This view on the age span of the Ceratite beds and the scope of the Scythian stage generally prevailed until Spath (1930, p. 76) published a preliminary scheme for the subdivision of the Scythian. This scheme is shown on Table 4. This is an extremely interesting modification of the earlier attempt to establish subdivisions of the Scythian. This zonal scheme was presented within a chapter discussing the age of the East Greenland early Triassic fauna (Spath, 1930) and prior to completion of the British Museum Triassic catalogue. This discussion is sufficiently brief and ambiguous as to leave unclear the complete justification and evidence for the proposal. The sequence of zones, except that of *woodwardi,* is that adopted by Noetling (1905) for the Ceratite beds of the Salt Range. This scheme differs in detail from the proposals and conclusions of previous authors but it agreed with several of these in having a single zone (*superbus*) to represent most of the upper Scythian. At the same time, within the upper Scythian, Spath (1930, p. 76) recognized three ages—the Owenitan, Columbitan, and Stephanitan.

Spath's 1930 proposal was the first new addition to Scythian chronology for quite some time. It was admittedly a tentative scheme in need of further analysis. What was critically lacking, especially for the upper part of the scale, were sufficient stratigraphic sections with these faunal zones in sequence. Spath was cognizant that Hyatt and Smith (1905) and Smith (1914) had reported Scythian ammonoid faunas in sequence in southeastern Idaho but up until the time of Spath's 1930 paper on East Greenland these faunas had been described only in a token fashion and stratigraphic data were very limited. Smith's (1932) monograph on the Lower Triassic ammonoids of North America provided a comprehensive treatment of these ammonoid faunas with data on their stratigraphic and geographic distributions. This monograph was a posthumous publi-

TABLE 4. SUBDIVISIONS OF LOWER TRIASSIC (SCYTHIAN) PROPOSED BY SPATH (1930)

	Ages	Zones (India)	Some Equivalents
Upper	Stephanitan		*Arctoceras* beds, Spitsbergen; *Olenekites* beds, N. Siberia
Upper	Columbitan	*superbus*?	*Columbites* beds, Albania; *Anasibirites* beds, Spitsbergen; Utah, Timor; *Tirolites* Beds, Werfen
Upper	Owenitan		*Meekoceras* beds, California *Meekoceras* beds, Timor;
Lower	Flemingitan	*flemingianus* *volutus* *fallax*	*Hedenstroemia* beds, Himalayas (lower part) "*Ophiceras*" beds, Timor
Lower	Gyronitan	*rotundatus* *radiosus*	"*Meekoceras*" beds, Himalayas *Proptychites* beds, Primorye
Lower	Otoceratan	*woodwardi*	*Proptychites* beds, Greenland *Otoceras* beds, Greenland

cation as Dr. J. P. Smith passed away on January 1, 1931. In southeastern Idaho, Smith encountered within the Thaynes Formation a sequence of three ammonoid faunas which formed the basis for part of his chronologic scheme for the Lower Triassic:

Columbites Zone
Tirolites Zone
Meekoceras Zone { *Anasibirites* Subzone; *Owenites* Subzone; *Pseudosageceras multilobatum* Subzone }
Genodiscus Zone
Otoceras Zone

The lower two zones—*Genodiscus* and *Otoceras*—had not been identified by Smith in western United States. The upper three zones were important for they occurred in stratigraphic superposition within the Thaynes Formation. Smith considered his *Anasibirites* Subzone to be equivalent to the fauna of the Upper Ceratite limestone of the Salt Range. Smith furthermore considered the specimen Waagen (1895, p. 130, pl. 21, figs. 1a-c) described as *Pseudharpoceras spiniger* as allied to his own species *Pseudharpoceras idahoensis* from the *Columbites* fauna of southeast Idaho and thus of *Columbites* Zone age. According to this stratigraphic scheme the Triassic formations of the Salt Range and the Trans-Indus Ranges included a complete sequence of faunal zones except for the *Otoceras* Zone and the *Tirolites* Zone. The Lower Ceratite limestone was assigned to the *Genodiscus* Zone, the Ceratite sandstone was assigned to the *Pseudosageceras multilobatum* Subzone (the Ceratite marls are not mentioned), the Upper Ceratite limestone was assigned to the *Anasibirites* Subzone, and the beds with *Pseudharpoceras spiniger*, presumably from the Topmost limestone of the Dolomite beds, were assigned to the *Columbites* Zone. This scheme, like that of Spath (1930), resulted in an enlarging of the scope of the Scythian and at the same time reducing the presumed degree of completeness of the Salt Range formations.

Smith's zonal scheme and analysis of the Scythian came under the searching pen of L. F. Spath (1933, 1934). Though Spath was rather caustic in his remarks on Smith's zonal schemes, the differences between these two authorities were not really all that great and were more apparent than real. In 1934, in the British Museum Catalogue on Triassic Cephalopoda, Spath presented a modified and more detailed scheme for subdivisions of the Lower Triassic (Table 5). The sequence of zones

TABLE 5. SUBDIVISIONS OF THE LOWER TRIASSIC (SCYTHIAN) PROPOSED BY SPATH (1934)

	Divisions	Zones	Equivalents
Upper Eo-trias	Prohungaritan (Olenikitan?)		Upper *Arctoceras* beds, Spitsbergen. Olenek beds, Siberia (partim). *P. middlemissi* beds, Kashmir.
			Subcolumbites beds, Albania, Timor.
	Columbitan	*Columbites*	*Columbites* beds, Idaho.
		Tirolites	*Tirolites* beds, Alps, etc., Idaho.
		Anasibirites	*Anasibirites* beds, Timor, Utah. Chocolate Limestone, Byans? Upper Ceratite limestone, Salt Range.
	Owenitan		*Kashmirites* beds, Kashmir, Timor.
		Owenites	*Meekoceras* beds, Timor, Idaho, California.
		Pseudosageceras	Timor, Himalayas, W. America.
	Flemingitan	*Flemingites flemingianus*	Ceratite sandstone, Salt Range.
		Koninckites voltus	Upper Ceratite marl, "
Lower Eo-trias		"*Celtites*" *fallax*	Middle Ceratite marls, Salt Range.
		Prionolobus rotundatus	Lower " " " "
	Gyronitan		Lower Ceratite limestone, Salt Range.
		"*Celtites*" *radiosus*	Primorye beds? *Proptychites* beds, E. Greenland.
			Ophiceras beds, Kashmir, E. Greenland.
	Otoceratan	*Ophiceras tibeticum* *Episageceras dalailamae* *Otoceras woodwardi*	*Otoceras* beds, Himalayas, E. Greenland.

for the Gyronitan and Flemingitan divisions is that proposed by Noetling (1905) for the sequence of faunas in the Lower Ceratite limestone, the Ceratite marl, and the Ceratite sandstone of the Ceratite beds in the Salt Range. For the Owenitan division Spath adopted Smith's (1932) scheme for his *Meekoceras* Zone but raised the subzones to zonal rank. The Upper Ceratite limestone was correlated with the *Anasibirites* Zone. *Pseudharpoceras* was not taken into account in this scheme. It can readily be seen that this zonal scheme differs from that proposed by Smith (1932) mainly in the assumption of a division above the Columbitan of one or more zones. In this conclusion Spath was guided mainly by "intuition" supported by the biologic character of the faunas. The stratigraphic data on the faunas he assigned to his Prohungaritan division were either completely lacking or very ambiguous. In his conclusions, explaining the significance of the Prohungaritan division, Spath (1934, p. 34) states: "I am merely relying on the obvious differences between the lowest Anisian and the highest Scythian faunas so far known, and the only difficulty is to find a name for this time interval that will prove sufficiently accurate to serve for a label, even if it is not the best that could ultimately be proposed." Spath's conclusions regarding additional zones above the *Columbites* Zone was verified with the discovery of a *Prohungarites* fauna in the Thaynes Formation of southeast Idaho 1,000 feet above the *Columbites* fauna (Kummel, 1954). This particular fauna contains faunal elements common to the *Subcolumbites* faunas of Tethys (Albania, Chios, Timor) and to the Olenek faunas that Spath included in his Prohungaritan division.

The strata included in the Mittiwali Member include zones of the Gyronitan, Flemingitan, and Owenitan divisions of

TABLE 6. SUMMARY OF NUMBER OF SPECIMENS AND NUMBER OF SPECIES RECOGNIZED BY WAAGEN (1895) IN THE TRIASSIC FORMATIONS OF THE SALT RANGE, WEST PAKISTAN

Horizon		Number of Species	Number of Specimens
Topmost limestone		1	1
Bivalve beds		3	7
Upper Ceratite limestone		37	45*
	Upper	12	18
Ceratite sandstone	Middle	21	24**
	Lower	11	17
Ceratite marls		20	44
Lower Ceratite limestone		21	38***
Unknown		12	13
	Total	138	207

* Three species Waagen stated as being represented by several specimens; these are not included here.
** One species from this horizon is listed by Waagen as being represented by several specimens and this is not included here.
*** One species from this horizon is listed by Waagen as being represented by several specimens and this is not included here.

Spath. The discovery of *Ophiceras connectens* by Schindewolf in the Kathwai Member and verified in my own field investigations, including the presence of a specimen of *Glyptophiceras*, clearly establishes the Otoceratan age of this member. It is now amply apparent that the Ceratite beds and the Upper Ceratite limestone of Waagen are not representative of the complete Scythian but at most include no more than two-thirds of that stage. The taxonomy of the ammonites from these Salt Range Triassic strata is sorely in need of revision. Of the 138 species described by Waagen in his 1895 monograph, 134 came from strata here classified as the Mittiwali Member of the Mianwali Formation. In general the Salt Range Triassic ammonites are not well preserved. Noetling (1901, p. 408) has pointed out that 99 species (approximately 70 per cent of Waagen's 138 described species) were based on a single specimen; of these half were stated to be poorly preserved and fragmentary specimens. Vredenburg (*in* Hayden, 1911, pp. 58–60) examined collections made by Noetling in 1899–1900 and made particular note of the weathered nature of many of Waagen's specimens. On Table 6 are listed the number of specimens Waagen (1895) had, and the number of species he recognized for each of his stratigraphic divisions. These data reflect well the statistics compiled by Noetling and quoted above.

My own field studies on the Kathwai and Mittiwali Members in the Salt Range and Surghar Range have yielded a very large collection of fossils. The specimens of many of these collections are of poor to moderate preservation. At the same time, a number of collections are of excellent preservation. All the type specimens of Waagen's 1895 monograph, that are still preserved, have been personally examined and photographed. In addition, the Paleontological Institute of Tübingen University and the British Museum (Natural History) have representative suites of Salt Range Triassic ammonites which have been examined. Studies of all these collections are well advanced but as yet not completed. The results to date show considerable change and revision of the systematics of these ammonoids; in addition, the zones (as recognized by Noetling [1905]) that have been accepted by most subsequent Triassic students do not reflect the actual vertical distribution of the genera and species and thus need a complete revision.

The most significant new aspect regarding the Triassic formations of the Salt Range is a clearer definition of the strata above the Upper Ceratite limestone, designated here as the Narmia Member of the Mianwali Formation. These strata have yielded a number of fragmentary and generally poorly preserved ammonites among which I have identified 15 species. Waagen (1895) described three species—*Dinarites sinuatus, Lecanites laqueus,* and *Lecanites planorbis*—from his "Bivalve beds" at Chhidru, and *Pseudharpoceras spiniger* from an unknown horizon (but thought to be the Topmost limestone) at Sheik-Budin Hills, in the Trans-Indus

Table 7. Geographic distribution of genera present in the Narmia Member of the Mianwali Formation

	Albania (*Subcolumbites* fauna)	Chios (*Subcolumbites* fauna)	Mangyshlak Peninsula	Salt and Surghar ranges, West Pakistan	Timor (*Prohungarites* fauna)	Kwangsi, China (*Subcolumbites* fauna)	Primorye region (*Subcolumbites* fauna)	Olenek region (*Olenekites* fauna)	Spitsbergen (*Keyserlingites* fauna)	Ellesmere Island (*Keyserlingites* fauna)	British Columbia (Toad-Grayling Formation)	Tobin Range, Nevada (*Subcolumbites* fauna)	Confusion Range Utah	S. E. Idaho (*Prohungarites* fauna)
Pseudosageceras	x	x	x	x			x	x					x	x
Subvishnuites	x			x										
Xenoceltites				x		x	x							
Procarnites	x	x	x	x	x	x	x				x			
Isculitoides	x	x		x	x	x	x				x	x		x
Anakashmirites				x										
Svalbardiceras				x				x	x	x	x			x
Stacheites				x								x		x
Dagnoceras	x			x	x	x								
Nordophiceras				x		x		x						
Arctomeekoceras				x				x						
Tirolites	x		x	x				x					x	
Prohungarites			x	x	x		x							x

region. The ammonite fauna of the Narmia Member, described here, includes the following species:

Pseudosageceras multilobatum Noetling
Subvishnuites sp. indet.
Xenoceltites sinuatus (Waagen)
Xenoceltites sp. indet.
Procarnites kokeni (Arthaber)
Isculitoides sp. indet.
Anakashmirites sp. indet.
Svalbardiceras sp. indet.
Stacheites sp. indet.
Dagnoceras sp. indet.
Nordophiceras planorbis (Waagen)
Nordophiceras cf. *planorbis* (Waagen)
Arctomeekoceras sp. indet.
Tirolites sp. indet.
Prohungarites cf. *crasseplicatus* (Welter)

For the purposes of clarifying the age of the Narmia Member, the species of *Procarnites*, *Stacheites*, *Arctomeekoceras*, *Isculitoides*, *Svalbardiceras*, *Dagnoceras* and *Prohungarites* are the most significant (Table 7). *Procarnites kokeni* is a prominent member of the *Subcolumbites* fauna of Albania, Chios, and Kwangsi, China and the *Prohungarites* fauna of Timor. Closely related species occur in the *Subcolumbites* beds at Cape Zhitkov, Primorye region, Siberia (Kiparisova, 1961), and in the "Toad-Grayling" Formation of British Columbia a few feet below *Keyserlingites subrobustus* (Tozer, 1965). The Scythian formations of the Mangyshlak Peninsula have yielded one species of *Procarnites*, *P. andrusovi* (Kiparisova, 1947), which appears to be conspecific with *P. kokeni*. Astakhova (1960b) lists *P. andrusovi* as occurring in her *Pseudosageceras* Zone which she correlated with the *Flemingites* beds of the Primorye region, the *Pseudosageceras* beds of North America, and *Pseudosageceras* and *Flemingites* beds of Timor. The only other species Astakhova lists as occurring with *Procarnites andrusovi* is *Pseudosageceras multilobatum*, a species that ranges throughout the Scythian. There is no basis whatsoever for the correlation she recommends; it is more likely that the greater part of the Mangyshlak sequence is of late Scythian *Prohungarites* Zone age. At least the Mangyshlak occurrence needs thorough checking. All other records of *Procarnites* and especially *Procarnites kokeni*, place it with *Subcolumbites* or *Prohungarites*.

The single specimen assigned to *Dagnoceras* is very similar to *Dagnoceras zappanense* from the *Subcolumbites* beds of Albania and the *Prohungarites* fauna of Timor. Related species are known from late Scythian horizons in Kwangsi, associated with *Hellenites*. *Isculitoides* is another genus common in late Scythian faunas. Species of this genus are known from the *Subcolumbites* faunas of Albania and Chios, the *Prohungarites* fauna of Timor, from Kwangsi, China associated with *Procarnites* and *Proptychitoides*, the *Subcolumbites* beds of the Primorye region, the "Toad-Grayling" Formation of British Columbia, the Tobin Formation of Nevada associated with *Subcolumbites*, and the Upper Thaynes Formation of southeastern Idaho associated with *Prohungarites* and *Keyserlingites*.

Svalbardiceras is known mainly from Arctic localities. It is present, associated with *Keyserlingites*, in the Olenek fauna of Siberia, in Spitsbergen, and in British Columbia. It is known from Ellesmere Island in association with *Olenekites*, and southeastern Idaho with *Keyserlingites* and *Prohungarites*. A single species of *Svalbardiceras* is known from the *Columbites* fauna of southeastern Idaho.

The form of *Prohungarites* recorded from the Narmia Member is very similar to the species listed as *Prohungarites* cf. *crasseplicatus* recorded from the Upper Thaynes Formation of southeastern Idaho (Kummel, 1954). Both the Salt Range and Idaho forms are, however, specifically distinct from the Timor *Prohungarites crasseplicatus*. The specimens assigned to *Arctomeekoceras* sp. indet. are the most abundant form in the Narmia fauna. They are most comparable to *Arctomeekoceras rotundatum* of the Olenek fauna on the Siberian coastal region. *Stacheites* was established for a species in the Werfen fauna of Muć, Dalmatia. In recent years several new species of the genus have been described, all from late Scythian faunas. The genus is represented in the *Subcolumbites* faunas of the Tobin Formation of Nevada. The genotype is also present in the highest Scythian faunal zone of the Mangyshlak Peninsula, associated with *Arnautoceltites* and *Leiophyllites* (Astakhova, 1960b).

Subvishnuites, *Xenoceltites*, and *Anakashmirites* are known mainly from mid-Scythian faunas. Their presence in the Narmia Member extends the range of these genera considerably. *Nordophiceras* was first described from the *Dieneroceras* Zone of Popov (1961) for the Siberian region. It is a very common form in the *Columbites* fauna of southeastern Idaho, a fauna I believe to be equivalent to that of the *Dieneroceras* Zone of Siberia. *Pseudosageceras multilobatum* is probably the most common and widespread species of Scythian ammonoids; it has no zonal significance except to mark the Scythian stage. *Tirolites* is mainly known as the principal element of the Werfen fauna of the Alpine region which is placed just below the *Columbites* Zone in our sequence of Scythian zones. The genus, however, is represented in the *Columbites* fauna of Idaho, in the *Subcolumbites* fauna of Albania, in late Scythian strata of northern Siberia, and in a late Scythian fauna in the Confusion Range of Utah (Silberling *in* Hose and Repenning, 1959, p. 2188).

Finally, there is the specimen Waagen (1895, p. 130, pl. 21, figs. 1a, b, c) described as *Pseudharpoceras spiniger*. This specimen was collected by Dr. Verchere in the Sheik-Budin area at Paniala Black Hills in the Trans-Indus region. The horizon was indicated as a yellow limestone at the base of the Variegated (Jura-Rhaetic) Series at the top of the Ceratite Formation. Waagen (1892a, b) concluded that this was the Topmost limestone unit of his

Dolomite group. The uncertainty of the horizon from which this specimen was collected has created differences of opinion by subsequent workers on the Salt Range Triassic. Noetling (1901, p. 406) was skeptical that the specimen actually came from the Triassic strata but since it did not come from the Salt Range he merely shrugged off the problem as without solution and did not mention it again in his later writings. Smith (1932, p. 81) accepted Waagen's genus "however unsatisfactorily founded and described" and described a new species, *Pseudharpoceras idahoense* from the *Columbites* fauna of southeastern Idaho. Smith also believed that *Tropiceltites praematurus* Arthaber (1911) from Albania "evidently belongs to *Pseudharpoceras*." In the first part of his Triassic catalogue, Spath (1934) mentions *Pseudharpoceras* only briefly. However, in the second part of his catalogue (Spath, 1951, p. 9) he concluded "the genus *Pseudharpoceras* may safely be rejected" because of its poor preservation and the uncertainty of its stratigraphic position. On rejection of Waagen's genus, he (Spath) accepted Smith's Idaho species and introduced a new generic name for it, *Pseudarniotites*. The rich and varied late Scythian fauna from Chios described by Renz and Renz (1948) contains a large representation of the forms Arthaber had assigned to *Tropiceltites*, for which Renz and Renz introduced the genus *Hellenites*. The species Smith (1932) described from the *Columbites* fauna is congeneric with these Albanian and Chios species of *Hellenites*, thus making *Pseudarniotites* a synonym (Kummel, *in* Arkell et al., 1957, p. L149).

Waagen's type specimen is not in the collections of the Geological Survey of India and is apparently lost. There is, however, a mold of a part of one side of the specimen and this is illustrated on Plate 4, figure 7, and a cast of this mold is shown on Plate 4, figure 6. Unfortunately, the mold has no trace of the venter. It can readily be seen that Waagen's illustrations of this species (1895, pl. 21, fig. 1) are highly restored. The morphological features that can be observed on the specimen and interpreted from Waagen's description show a close relationship to the Albanian and Chios species placed in *Hellenites* and to the Idaho species that Smith (1932) placed in *Pseudharpoceras*. However, because that all that remains is a partial mold of the poorly preserved only specimen, and because the stratigraphic horizon of the specimen is in doubt, I agree with Spath that the genus and species had best be suppressed.

The assemblage of species in the Narmia Member is considered to be of late Scythian age encompassing the Prohungaritan division of Spath (Table 5). Late Scythian faunas are now known from Albania, Chios, the Mangyshlak Peninsula, West Pakistan, Kashmir, Timor, New Zealand, China, Japan, Primorye region, northern Siberia, Spitsbergen, Ellesmere Island, British Columbia, Nevada, and Idaho. These late Scythian faunas are large and diverse, including 59 genera. A complete taxonomic revision of all these faunas [by me] is nearing completion. One of the conclusions of that study is that there is only one zone of Scythian ammonoids above the *Columbites* Zone. There are regional faunal differences, but these I do not believe reflect any significant time difference, but rather to be due to biological, lithofacies, geographic factors, and to factors of preservation. One handicap in the interpretation is the lack of stratigraphic data for many of these faunas. For instance, the Albanian, Chios, Timor, Japanese, New Zealand, and Nevada (Tobin Formation) faunas are stratigraphically isolated with neither younger nor older faunas in known sequence. Fairly good stratigraphic data are available for most of the other localities listed above. Six of the genera of the Narmia fauna (*Procarnites, Isculitoides, Svalbardiceras, Dagnoceras, Arctomeekoceras,* and *Prohungarites*) are restricted to horizons containing *Subcolumbites, Prohungarites, Keyser-*

lingites, etc. Three of the genera (*Stacheites*, *Nordophiceras*, and *Tirolites*) occur in some of these late Scythian faunas but also occur in the underlying *Columbites* or *Tirolites* zones. The remaining genera are more long ranging forms.

SYSTEMATIC PALEONTOLOGY

Class CEPHALOPODA Cuvier, 1797
Subclass AMMONOIDEA Zittel, 1884
Family SAGECERATIDAE Hyatt, 1900
Genus *Pseudosageceras* Diener, 1895
Type species, *Pseudosageceras multilobatum* Noetling, 1905

Pseudosageceras multilobatum Noetling, 1905
Plate 1, figures 11, 12

Pseudosageceras multilobatum Noetling, 1905, p. 181, pls. 19–27; Frech, 1905, pl. 23, figs. 4, 5, pl. 25, fig. 1, pl. 26, fig. 3; Krafft and Diener, 1909, p. 145, pl. 21, fig. 5; Wanner, 1911, p. 181, pl. 7, fig. 4; Diener, 1915, p. 237; Diener, 1917, p. 173, pl. 1, fig. 13; Welter, 1922, p. 94, fig. 3; Diener, 1925, p. 96, fig. 26; Smith, 1932, p. 87, pl. 4, figs. 1–3, pl. 5, figs. 1–6, pl. 25, figs. 7–16, pl. 60, fig. 32, pl. 63, figs. 1–6; Kutassy, 1933, p. 630; Collignon, 1933, p. 24, pl. 11, fig. 2; Spath, 1934. p. 54, fig. 6a; Kiparisova, 1947, p. 127, pl. 25, figs. 3–4; Kummel, 1954, pp. 185–187; Chao, 1959, p. 183, pl. 1, figs. 9, 12; Silberling, *in* Hose and Repenning, 1959, p. 2194; Astakhova, 1960b, p. 149; Tozer, 1961, p. 44, pl. 13, figs. 8, 9; Astakhova, 1962, p. 75.

Pseudosageceras intermontanum Hyatt and Smith, 1905, p. 99, pl. 4, figs. 1–3, pl. 5, figs. 1–6, pl. 63, figs. 1, 2; Mathews, 1929, p. 3, pl. 1, figs. 18–22; Renz, 1945, p. 301; Renz, 1947, p. 175; Renz and Renz, 1947, p. 62; Renz and Renz, 1948, p. 90, pl. 16, figs. 4, 7.

Pseudosageceras multilobatum var. *giganteum* Kiparisova, 1947, p. 127, pl. 26, figs. 2–5; Popov, 1961, p. 13, pl. 2, figs. 1, 2.

Pseudosageceras cf. *multilobatum*, -Kiparisova, 1961, p. 30, fig. 3.

Pseudosageceras schamarense Kiparisova, 1961, p. 31, pl. 7, figs. 3, 4.

Five fragmentary specimens of poor to fair preservation are in the collection. It is the characteristic shape of the conch and the suture that allows the identification.

This species is the longest ranging of any Scythian ammonoid and is present practically everywhere that Scythian deposits occur. It apparently has not been recorded as yet from the lowest Scythian *Otoceras* Zone, but is present throughout the remainder of the Scythian. In the Salt Range it is well represented in the Mittiwali Member (Lower Ceratite limestone and the Ceratite marls) of the Mianwali Formation.

Occurrence. All five specimens recorded here are from the Narmia Member of the Mianwali Formation. Three specimens are from Landa Nala in the Surghar Range, one from a 3.5 foot bed of limestone 20 feet above the base of the member (bed no. 5) another from a 7 foot limestone bed 40 feet above the base of the member (bed no. 9), and the last 18 inches above the basal limestone of the Narmia Member, Mianwali Formation (bed no. 2). The fourth specimen came from a 5 foot bed of limestone in Narmia Nala, 38 feet above the base of the Narmia Member (bed no. 32). The fifth specimen came from an 8 foot bed of limestone in Nammal Gorge 126 feet above the base of the Narmia Member (bed no. 34).

Repository. Figured specimens (Pl. 1, figs. 11, 12) MCZ 9578; unfigured specimens from bed no. 2 in Landa Nala MCZ 9580, from bed no. 5 in Landa Nala MCZ 9576, from bed no. 9 in Landa Nala MCZ 9577, from bed no. 34 in Nammal Gorge MCZ 9579.

Family DIENEROCERATIDAE Kummel, 1952
Genus *Subvishnuites* Spath, 1930
Type species, *Subvishnuites welteri* Spath, 1930

Subvishnuites sp. indet.
Plate 3, figures 1–5

Three horizons in the Narmia Member yielded seven fragmentary and/or highly weathered specimens that can be assigned to this genus on the basis of their sharp venter. The better preserved specimens are merely small fragments of phragmocone. There are two more or less complete specimens, though badly weathered, that do show the evolute nature of the conch; likewise, it is almost certain that the inner whorls, as the later ones, are devoid of any ornamentation. The suture is shown on Figure 22J.

The type-species of *Subvishnuites*, *Vishnuites* sp. Welter (1922, p. 137, pl. 147, figs. 3–5 = *Subvishnuites welteri* Spath, 1930, p. 30), was based on a single specimen from the *Owenites* fauna of Timor. Conspecific forms have been described by Kummel (1959, p. 443, fig. 7) from an *Owenites* fauna in South Island, New Zealand, by Popov (1962b, p. 43, pl. 6, fig. 3—as *Parinyoites mastykensis*) from an *Owenites* fauna of the Caucasus Mountains, and by Kummel and Erben (1966) from an *Owenites* fauna in Afghanistan. *Subvishnuites tientungensis* Chao (1959) from the *Owenites* Zone of Kwangsi, China, is a valid species of this genus, quite distinct from *S. welteri*. I have in manuscript the description of a species from the *Columbites* fauna of southeastern Idaho. *Inyoites eiekitensis* Popov (1962a) I believe to be a species of *Subvishnuites*. It is said to come from the *Dieneroceras* Zone of Siberia, which Popov considered as equivalent to the *Anasibirites* Zone, but the associated species suggest a correlation with the *Columbites* Zone of southeastern Idaho.

All of these species and records of *Subvishnuites* are based on one or very few specimens; there is obviously a great deal yet to be learned about this generic group. The Pakistan specimens are too poorly preserved to make any meaningful comparisons with the known species of the genus. My specimens exhibit the basic morphological characters of the genus. It should be emphasized that they are the youngest specimens of the genus recorded to date.

Occurrence. Narmia Member of Mianwali Formation from: (1) a 3.5 foot bed of limestone 20 feet above the base of the Narmia Member (bed no. 5) in Landa Nala, Surghar Range; (2) a 7 foot bed of limestone 29 feet above the base of the Narmia Member (bed no. 7) in Landa Nala, Surghar Range; (3) bed 30, 32, and 36, all limestone units 17, 38, and 76 feet, respectively, above the base of the Narmia Member, Narmia Nala, Surghar Range, West Pakistan.

Repository. Figured specimens (Pl. 3, fig. 1) MCZ 9596, (Pl. 3, figs. 2, 3) MCZ 9597, (Pl. 3, figs. 4, 5) MCZ 9598; suture specimen MCZ 9599; unfigured specimens from Landa Nala MCZ 9610; unfigured specimens from Narmia Nala MCZ 9600, MCZ 9602.

Family XENOCELTITIDAE Spath, 1930
Genus *Xenoceltites* Spath, 1930
Type species, *Xenoceltites subevolutus* Spath, 1930

Xenoceltites sinuatus (Waagen), 1895
Plate 1, figures 1–8

Dinarites sinuatus Waagen, 1895, p. 33, pl. 10, fig. 4; Diener, 1915, p. 122.
Xenoceltites sinuatus, -Chao, 1959, p. 194.
Lecanites laqueus Waagen, 1895, p. 285, pl. 38, figs. 9, 10.
Xenodiscus laqueus, -Diener, 1915, p. 313.

Waagen (1895, p. 33) established this species on a weathered, one-third volution of body chamber (Pl. 1, figs. 1, 2). Waagen's original illustrations of this species are fairly accurate but he included a portion of a penultimate whorl which at least at present is not part of the specimen. My own collections contain two specimens collected from the same bed and at the same locality as Waagen's type. The specimens are in a friable sandstone and in their preservation leave much to be desired. The best of the two specimens (Pl. 1, figs. 3, 4) consists of one-third volution of phragmocone; the other specimen is more complete and shows the inner whorls, but the preservation in general is very poor. *Lecanites laqueus* was established by Waagen on the basis of two very poorly preserved and fragmentary specimens (Pl. 1, figs. 5–8). They were collected from the same beds and the same locality as the type of *X. sinuatus*. There is no question but they are conspecific with the type of *X. sinuatus*.

The key feature of this species is the evolute conch with compressed elliptical whorls. The whorl sides bear prominent, slightly forwardly projecting ribs; the venter is smooth. The suture, which was unknown to Waagen, is well developed on my illustrated specimen and is reproduced here on Figure 22H.

Xenoceltites is represented by a diverse and geographically widespread group of species in the mid-Scythian; in the upper Scythian, however, few species (or even specimens) have been recorded. The classic upper Scythian faunas of Albania, Chios, and Timor have no species of *Xenoceltites* nor are any known as yet from western North America. Species of *Xenoceltites* in late Scythian deposits are known from Utah (Silberling, *in* Hose and Repenning, 1959), Kwangsi, China, and two regions in Siberia, but none of these are morphologically particularly close to *X. sinuatus*. The species (or specimen) that shows the greatest similarity to *X. sinuatus* is *X. spitsbergensis* Spath (1934, pl. 9, figs. 2a, b) from the *Arctoceras* (= *Owenites*) beds of Spitsbergen, presumably a much older species.

The Kwangsi species, *Xenoceltites crenoventrosus* Chao (1959, p. 194, pl. 3, figs. 14–15; pl. 42, figs. 2–6), comes from beds containing a typical *Subcolumbites* fauna. Its suture is quite similar to *X. sinuatus* but the rib pattern is quite distinct. Kiparisova (1961, p. 50) assigned a few small specimens from the *Subcolumbites* beds of the Primorye region to *Xenoceltites spitsbergensis* Spath. I am willing to accept the assignment of these forms to *Xenoceltites*, but have serious doubts on the species relationships. These Primorye forms, at least, have no similarity to *X. sinuatus*. Finally, I believe the Olenek fauna contains *Xenoceltites*, namely the whole group of species Mojsisovics (1886) placed in his group "obsoleti" (Kummel, 1961, p. 521). This includes *Ceratites multiplicatus*, *C. hyperboreus*, *C. fissiplicatus*, and *C. discretus*, all new species described by Mojsisovics in his 1886 monograph on the Olenek fauna. Some of these forms (e.g., *Ceratites multiplicatus* Mojsisovics, 1886, pl. 9, figs. 15a, b) are quite similar in many aspects to *X. sinuatus*.

Occurrence. Waagen's type specimens and the two specimens recorded here came from sandstone beds of the Narmia Member above the hard "Bivalve limestone" on the east side of Chhidru Nala, Salt Range, West Pakistan.

Repository. Holotype (Pl. 1, figs. 1, 2) GSI 7110; syntypes *Lecanites laqueus* (Pl. 1, figs. 5–8) GSI 7221, 7222; topotype (Pl. 1, figs. 3, 4) MCZ 9581; unfigured specimen MCZ 9582.

Xenoceltites sp. indet.
Plate 1, figures 9, 10

A fragmentary specimen consisting of slightly more than one-third volution of living chamber. The whorls are compressed, venter rounded, flanks only slightly convex. Whorls marked by slightly forward projecting grooves which cross the venter. The specimen is possibly conspecific with *Xenoceltites sinuatus* (Waagen), but the differences which are apparent in light of the fragmentary record of both suggest that separate treatment of this form at this time is warranted.

Occurrence. From 10 foot bed of limestone 17 feet above base of Narmia Member (bed no. 30) of the Mianwali Formation in Narmia Nala, Surghar Range, West Pakistan.

Repository. MCZ 9583.

Family PROPTYCHITIDAE Waagen, 1895
Genus *Procarnites* Arthaber, 1911
Type species, *Parapopanoceras kokeni* Arthaber, 1908

Procarnites kokeni (Arthaber), 1908
Plate 2, figures 10–13

Parapopanoceras kokeni Arthaber, 1908, p. 259, pl. 11(1), figs. 1a–c, 2a, b.

Hedenstroemia sp. Arthaber, 1908, p. 284, pl. 3, fig. 2.

Procarnites kokeni, -Arthaber, 1911, p. 215, pl. 17(1), figs. 16, 17, pl. 18(2), figs. 1–5; Diener, 1915, p. 228; Diener, 1917, p. 167; C. Renz, 1928, p. 155; Renz and Renz, 1947, p. 61; Renz and Renz, 1948, p. 81, pl. 8, figs. 5, 6–6a, 7–7a, 8–8a, 9–9a, pl. 9, figs. 2–2a.

Procarnites kokeni var. *evoluta* Renz and Renz,

1947, p. 61; Renz and Renz, 1948, p. 82, pl. 9, figs. 1–1a.
Procarnites kokeni var. *panteleimonensis* Renz and Renz, 1947, p. 61, 78; Renz and Renz, 1948, p. 82, pl. 8, figs. 3–3a, pl. 9, figs. 3–3a.
Procarnites acutus Spath, 1934, p. 183, pl. 5, figs. 4a, b (= *Hedenstroemia* sp. Arthaber, 1908, p. 284, pl. 3, fig. 2); Chao, 1959, p. 89, 255, pl. 32, figs. 8–9, pl. 33, figs. 1–8.
Procarnites skanderbegis Arthaber, 1911, p. 216, pl. 18(2), figs. 6, 7; Diener, 1915, p. 229; C. Renz, 1928, p. 155; Renz and Renz, 1947, p. 61; Renz and Renz, 1948, p. 82, pl. 8, figs. 4–4a.
Procarnites andrusovi Kiparisova, 1947 (Bajarunas, 1937, *nom. nud.*), p. 132, pl. 28, figs. 2–4, text-figs. 11–13; Astakhova, 1960b, p. 149.
Procarnites oxynostus Chao, 1959, p. 88, 254, pl. 32, figs. 1–7, 10–12, text-fig. 28a–d.

The lower part of the Narmia Member at its type locality in Narmia Nala has yielded three small specimens of this very diagnostic species. The most complete specimen (Pl. 2, figs. 10, 11) measures 23.2 mm in diameter, 8.6 mm for the width of the whorl, 11.6 mm for the height of the whorl, and 3.5 mm for the diameter of the umbilicus. The specimen which yielded the suture (Fig. 22I) consists of one-half volution of approximately 27 mm in diameter. The third specimen is a small fragment of phragmocone of only five septa. All the specimens are phragmocones.

A comprehensive review of the genus *Procarnites*, and all the species that have been assigned to it has been completed for a broad review of all Scythian ammonoids. Only a summary of this review need be given here to clarify the identity and biological affinities of the specimens recorded here.

The two syntypes of *Procarnites kokeni* (Arthaber) are small, immature specimens. Only one side of either of these specimens is preserved. Noteworthy of the smaller of these two specimens are the broadly arched lateral areas and the round umbilical shoulders; the other specimen (the paralectotype) has broader lateral areas and abruptly rounded umbilical shoulders and nearly vertical umbilical walls. These two syntypes of Arthaber's are comparable in size to the two most complete specimens recorded here. In the shape of the whorl, nature of the venter, umbilical diameter. etc., the Salt Range specimens are nearly identical to the two Albanian primary types. The suture (Fig. 22I) likewise is very similar. As with most of the specimens from the *Subcolumbites* fauna of Albania the suture can be exposed only by grinding and polishing. This has been done on Arthaber's two type specimens, and in the process details of the denticulation patterns of the lobes are, of course, obliterated. The basic pattern of the suture of the Salt Range specimens is identical to that of the Albanian specimens, and the small differences which are present fall within the range of what can be expected as intra-specific variation.

In his monograph on the Kčira, Albania fauna, Arthaber (1911) stated he had 45 specimens for study and he illustrated six of these. Unfortunately, only three of the illustrated specimens are still available. In addition to *Procarnites kokeni*, Arthaber (1911) recognized one additional species, *P. skanderbegis*. For this species he records eight specimens of which the two illustrated syntypes are available. This species was differentiated on the basis of suture, degree of conch inflation, and ornamentation. In regards to the suture, it was the absence of minor adventitious elements in the ventral lobe to which Arthaber pointed. The modification and development of the suture in the ventral region progressively changes with growth, and on comparing the suture of *P. skanderbegis* with that of *P. kokeni* it is seen that they differ in only the smallest details.

Assessment of the significance of conch shape and ornamentation was not possible until the discovery of the *Subcolumbites* fauna of Chios which yielded a large number of specimens of *Procarnites*. A plot of the measurements of the Chios specimens assigned by Renz and Renz (1948) readily shows that no distinction can be made between these two species on the basis of whorl height or umbilical diameter. In respect to whorl width, the specimens assigned to *P. skanderbegis* tend to be thicker, but there is complete gradation with the more compressed forms which had been placed in *P. kokeni*.

The ornamentation of the larger of Arthaber's two syntypes consists of very faint radial folds and slightly accentuated growth lines every millimeter or so. The specimen is not well preserved, so the complete pattern of this ornamentation is not known. The smaller syntype does not show any ornamentation. None of the specimens from Chios assigned by Renz and Renz to *P. skanderbegis* show any ornamentation. Two specimens of *P. kokeni* (Renz and Renz, 1948, pl. 8, figs. 3, 5, pl. 9, fig. 3) show faint radial ribs or falcoid ribs. The poor state of preservation of the Albanian and Chios *Subcolumbites* fauna is an important factor which does not allow full evaluation of the nature and variation of the ornamentation patterns. On the basis of the data available, ornamentation does not appear to be a criterion which can be used in this case for species discrimination. Thus the criteria used to distinguish *P. skanderbegis* from *P. kokeni* do not stand up on close examination.

Spath (1934, p. 183) separated one of Arthaber's varieties of *Procarnites kokeni* as a new species—*P. acutus*. The distinction was made on the basis of an acute to oxynote venter. He (Spath) also mentions a form which he considered transitional with *P. kokeni* from the same Albanian *Subcolumbites* fauna. Examination of the large number of specimens of *P. kokeni* from Chios clearly shows complete gradation from forms with acute venters like Spath's holotype of *P. acutus* (Spath, 1934, pl. 5, figs. 4a, b) to forms with broadly rounded venters.

Procarnites andrusovi (Kiparisova, 1947) from the Mangyshlak Peninsula of the Caspian region appears to be conspecific with *P. kokeni*. Kiparisova distinguished her species on the basis of the greater width of the umbilicus and the addition of an adventive element in the ventral lobe. The umbilical width of *P. andrusovi* falls well within the variability in this feature in the population of *P. kokeni* from Chios. Variation in the ventral lobe is a function of ontogeny. Unfortunately, the stratigraphic relations of the Mangyshlak Scythian ammonoids described to date are not well known. The data given by Bajarunas (1936) and Kiparisova (1947) are ambiguous. The recent description of several species of Scythian ammonoids from Mangyshlak by Astakhova (1960a) did not include any discussion of *P. andrusovi*, but, in two stratigraphic papers, Astakhova (1960b. 1962) lists this species as part of her *Pseudosageceras* fauna that she thought to be of Owenitan age.

Chao (1959) recognized two species of *Procarnites* from Kwangsi, China. He had four specimens he assigned to *P. acutus* Spath and six specimens for which he erected a new species, *P. oxynostus*. From the measurements of the basic conch parameters given by Chao, it is readily seen that these forms are very much like the population of *P. kokeni* from Chios. In terms of whorl width they are clearly of the compressed variety, but yet fall within the range of variation of this feature as exhibited in the population from Chios. The minor differences in the suture, pointed to by Chao, are more likely expressions of poor preservation than of any real genetic significance.

The second species of *Procarnites* which I recognize is *P. immaturus* (Kiparisova, 1947, p. 130). This species is from the *Subcolumbites* beds of Cape Zhitkov, Primorye region, Siberia. It is very similar to *P. kokeni* but is distinguished on the basis of faint radial constrictions. *Procarnites modestus* Tozer (1965), from an upper Scythian horizon in the Toad Formation of British Columbia, I believe to be a synonym of the Primorye *P. immaturus* Kiparisova.

Occurrence. The three small specimens recorded here came from the lower part of the Narmia Member of the Mianwali Formation (17 feet above the base of the member, bed no. 30) in Narmia Nala, Surghar Range, West Pakistan.

Repository. MCZ 9593 (Pl. 2, figs. 10, 11), MCZ 9594 (Pl. 2, figs. 12, 13), MCZ 9595 (suture specimen, Fig. 22I).

Family PARANANNITIDAE Spath, 1930
Genus *Isculitoides* Spath, 1930
Type species, *Isculites originis* Arthaber, 1911

Isculitoides sp. indet.

The collections include four weathered and very poorly preserved specimens. They are very involute, globular, forms, with what appears to be a very small, excentric umbilicus. The suture is visible only in vague segments; these suggest a simple ventral lobe and a single lateral lobe. The assignment of these specimens to this genus is coupled with the conclusion that the Narmia Member is of late Scythian age; there is no other genus of this age with these morphological characters.

Isculitoides is a very characteristic and widespread genus of upper Scythian ammonoids. The type species, *I. originis* (Arthaber), is present in the *Subcolumbites* fauna of Albania and Chios and in the *Albanites-Prohungarites* fauna of Timor. In Kwangsi, China, Chao (1959) has recorded *I. ellipticus* from loose blocks which also contained *Procarnites* and *Proptychitoides*, suggesting the late Scythian *Subcolumbites* age. The specimens Kiparisova (1961) described as *Parananmites suboviformis* from the *Subcolumbites* beds of the Primorye region are more correctly assigned to *Isculitoides*. Tozer (1965) has described *I. minor* from late Scythian strata (associated with *Keyserlingites*, *Svalbardiceras*, etc.) from northeastern British Columbia. I have descriptions of two new species, in manuscript, from western United States. One is in the Toad Formation of Nevada, associated with *Subcolumbites*, and the other in the Thaynes Formation associated with *Keyserlingites* and *Prohungarites*.

Small, globular, tightly involute forms such as *Isculitoides* are very difficult to analyze unless large populations of fairly good preservation are available. Most of the species recognized to date are known from relatively few specimens. The only large population of a species of this genus known to the writer is that of *I. originis* from the *Subcolumbites* fauna of Chios. Analysis of this population shows a very great range in variation in practically all conch parameters. It is highly possible that at least some of the species mentioned above are actually synonyms of *I. originis*. The stratigraphic range of the genus appears to be restricted to the uppermost Scythian *Subcolumbites-Prohungarites* Zone.

Occurrence. The four specimens came from a two foot bed of limestone 76 feet above the base of the Narmia Member (bed no. 36) of the Mianwali Formation, Narmia Nala, West Pakistan.

Repository. MCZ 9616.

Family KASHMIRITIDAE Spath, 1930
Genus *Anakashmirites* Spath, 1930
Type species, *Danubites nivalis* Diener, 1897

Anakashmirites sp. indet.
Plate 3, figures 6–8

The Narmia Member at Landa and Narmia Nala in the Surghar Range has yielded a number of fragments of phragmocones of a very evolute species. The whorls are oval, compressed, and bear blunt widely spaced ribs that enlarge toward the ventral shoulder. Most of the specimens appear to be crushed to a greater or lesser extent. None of the specimens are complete enough to yield any significant measurements. The suture is shown on Figure 22F.

Evolute ammonoids with radial ribs are fairly common through most of the Scythian. The taxonomy of these forms, however, is in a most unsatisfactory state. Of the several genera of these forms, the type of *Anakashmirites* and related species are most similar to the Pakistan specimens recorded here. Most of the generally accepted species of *Anakashmirites* are known from the *Owenites* Zone.

In none of the classic uppermost Scythian faunas of Albania, Chios, Timor, Kwangsi, Primorye region, northern Siberia, or western United States are there species that could be considered "typical" *Anakashmirites.* The basic form of the whorl section and ribbing pattern is similar to several species of *Anakashmirites* from the mid-Scythian *Owenites* Zone, but the suture is distinctly more advanced. Under the circumstances, we can consider this identification as merely tentative; at the moment there is no other logical group that would include these forms.

Occurrence. Narmia Member of Mianwali Formation from (1) a 7 foot bed of limestone 40 feet above the base of the Narmia Member (bed no. 9) in Landa Nala, and (2) a 10 foot bed of limestone 17 feet above the base of the Narmia Member (bed no. 30) in Narmia Nala, Surghar Range, West Pakistan.

Repository. Figured specimens (Pl. 3, figs. 6, 7) MCZ 9603, (Pl. 3, fig. 8) MCZ 9604; unfigured specimens from Landa Nala MCZ 9601, unfigured specimens from Narmia Nala MCZ 9608.

Family MEEKOCERATIDAE Waagen, 1895
Genus *Svalbardiceras* Frebold, 1930
Type species, *Lecanites* (?) *spitzbergensis* Frebold, 1929b

Svalbardiceras sp. indet.
Plate 2, figures 6–9

This genus is recognized on the basis of a nearly complete phragmocone of only fair preservation, and a fragment of another. The more complete specimen measures 29 mm in diameter, 6.2 mm for the width of the adoral whorl, 11.8 mm for the height, and 9 mm for the diameter of the umbilicus. The whorls are compressed, broadly convex. The venter is flat and aligned by subangular ventral shoulders. The umbilical shoulders are rounded with a low but steep umbilical wall. No shell is preserved but the adoral half volution bears faint, low, radial ribs. The inner whorls, at a diameter of 5.5 mm are well preserved; at this stage the venter is rounded, the whorls are approximately as wide as high and bear periodic constrictions across the whorl sides and venter. In addition, there are blunt nodes on the flanks. The suture is shown on Figure 22G.

The genus *Svalbardiceras* has been plagued by confusion since its introduction by Frebold (1930). That author quite clearly indicated *Lecanites* (?) *spitzbergensis* Frebold (1929b, p. 299, pl. 1, fig. 1) as the type; nevertheless, Spath (1934, p. 251) listed *Svalbardiceras spitzbergense* Frebold (1930, p. 24, pl. 4, figs. 1, 12) as lectotype. Unfortunately, the specimen described by Frebold in 1929b was destroyed in the great fire of 1943 that burned out Hamburg. The type specimen came from an horizon separate and above the *Arctoceras* beds near Agardhbay, west Spitsbergen. In the same year, Frebold described two specimens from Kap Thordsen in Eisfjord, west Spitsbergen, as *Ammonites* sp. indet. (Frebold, 1929a, p. 13, 14, pl. 1, figs. 12, 13) which he thought to be similar to his *Lecanites* (?) *spitzbergensis.* I believe these specimens to be conspecific to the type specimen from Agardhbay. The Kap Thordsen specimens are associated with *Keyserlingites.* In the next year, Frebold (1930) illustrated three additional examples of *Svalbardiceras spitzbergensis* and brought out again its stratigraphic position as being above the *Arctoceras* fauna. Frebold (1930, p. 25) states his species was found in his Grippia beds and the lower part of the Saurian beds, both of which he considered of Anisian age, a conclusion he reaffirmed in 1951. However, Tozer (1961, p. 32) quotes a personal communication from Frebold on the association of *Svalbardiceras spitzbergensis* and *Beyrichites affinis* in the lower Saurian beds as follows: "Dr. Frebold informed the writer (personal communication) that he was never completely satisfied that *Svalbardiceras* occurs with *Beyrichites affinis.* In the sections that he examined (Frebold, 1931) no such association was apparent." It is quite apparent that *Sval-*

bardiceras spitzbergensis is widespread in Spitsbergen and its association with *Keyserlingites subrobustus* (Tozer, 1961) at Botneheia, Sassenfiord, and at Kap Thordsen indicates that we are dealing with a late Scythian horizon equivalent to the *Olenekites* fauna of northern Siberia.

The *Olenekites* fauna contains at least three species of *Svalbardiceras*, *S. schmidti* (Mojsisovics), *S. dentosus* (Mojsisovics) and *S. sibiricum* (Mojsisovics). Popov (1961) established the genus *Nordophiceras*—type species *Xenodiscus karpinskii* Mojsisovics (1886, p. 87, pl. 11, fig. 13)—for a variety of species described by Mojsisovics (1886) as *Xenodiscus schmidti, Xenodiscus dentosus*, and *Xenodiscus euomphalus.* Thus within the genus *Nordophiceras*, Popov (1961) combined what I consider to be a heterogeneous assemblage of species including forms with rounded venters and others with flat venters. Popov (1961) recognized that *Xenodiscus schmidti* was very similar to *Svalbardiceras spitzbergensis* Frebold, but, on the argument that the suture of this latter species was unsatisfactorily defined, and that the suture was unknown, he felt a comparison was not possible. It is true that no drawing of the suture was presented with the original description of *Lecanites* (?) *spitzbergensis* Frebold (1929b, p. 299, pl. 1, fig. 1), but they are visible on the photograph of the specimen. Frebold interpreted the lobes of this specimen as being goniatitic. One of the two specimens from Kap Thordsen, which Frebold (1929a) described as *Ammonites* sp. indet., I believe is conspecific with the type of *Svalbardiceras*; it has two denticulated lateral lobes and a smooth auxiliary lobe on the umbilical wall. *Nordophiceras* should be restricted to forms with rounded venters like the type species *Xenodiscus karpinskii* Mojsisovics. Both the Spitsbergen and the Olenek species of *Svalbardiceras* are known from very few specimens. *Svalbardiceras schmidti* differs from *S. spitzbergensis* mainly in being more involute.

Of the other two species of *Svalbardiceras* in the Olenek fauna, *S. dentosus* is unique for the low clavi along its sharp ventral shoulders, and *S. sibiricum* for its great involution of the conch. The latter species was first listed by Popov (1961, p. 7) as a representative of *Boreomeekoceras*, and later (Popov, 1962a, p. 176, 186) as a species of *Hemiprionites*. Tozer (1965, p. 37) has correctly pointed out the errors of these identifications.

Recently Tozer (1965) has described *Svalbardiceras freboldi*, from beds with *Olenekites* on Ellesmere Island, and *Svalbardiceras chowadei*, from the Toad Formation of British Columbia, in actual or close association with *Keyserlingites subrobustus.* These two species differ very little from *S. spitzbergensis* and *S. schmidti*.

A fragmentary specimen from the Upper Thaynes Formation has been recorded by Kummel (1954, p. 187) as *Svalbardiceras* sp. The description of this species is in manuscript awaiting publication. The specimen came from a fauna which included species of *Keyserlingites* and *Prohungarites.*

The *Columbites* fauna of southeastern Idaho has yielded a single well preserved specimen of a new species of *Svalbardiceras.* The description of this species is also in manuscript awaiting publication.

The known species of *Svalbardiceras* are confined mainly to the circum-arctic region and to the cordilleran belt of western North America. The specimens from West Pakistan are too fragmentary to identify at a species level or to make significant comparisons with the other species of the genus. It suffices to say that all of the known species of *Svalbardiceras* appear to form a close genetic unit, and that morphological differences between species are not very great. Finally, the stratigraphic position of all species is clearly late Scythian.

Occurrence. From an 8 foot bed of limestone 126 feet above the base of the Narmia Member (bed no. 34) of the Mianwali Formation, Nammal Gorge, West Pakistan.

Repository. Figured specimen (Pl. 2,

figs. 6–9) MCZ 9587; unfigured specimen MCZ 9588.

Genus *Dagnoceras* Arthaber, 1911
Type species, *Dagnoceras nopcsanum* Arthaber, 1911

Dagnoceras cf. *zappanense* Arthaber
Plate 3, figures 9, 10

Dagnoceras zappanense Arthaber, 1911, p. 241, pl. 21(5), figs. 8, 9; Diener, 1915, p. 115; Spath, 1934, p. 268–271, pl. 7, fig. 2, text-fig. 93d, e, f.

This species is recognized on the basis of a fragmentary specimen of one-third volution, preserved only on one side. One suture is clearly visible and the remainder of the specimen is presumably body chamber. The venter is rounded, ventral and umbilical shoulders also rounded, the flanks broadly convex. There is a single broad, low, bulge starting at the umbilical shoulder and extending half way down the flank. The specimen is identified mainly on its very distinctive suture which consists of a long, narrow, first lateral lobe on the mid region of the flanks, and a small second lateral lobe on the umbilical shoulder (Fig. 22A).

In terms of whorl shape and suture, this specimen is most similar to *Dagnoceras zappanense* Arthaber from the *Subcolumbites* fauna of Albania. *Dagnoceras* is represented in the Albanian fauna by two species—*D. zappanense* and *D. nopcsanum* Arthaber. The former species is also known from the *Albanites* fauna of Timor. The genus is also known from Kwangsi, China, in beds associated with *Hellenites*, *Prenkites*, etc. (Chao, 1959). As yet, very few species and specimens of the genus are known, but all the specimens known to date are from the late Scythian.

Occurrence. From a 10 foot bed of limestone 17 feet above the base of the Narmia Member (bed no. 30), Mianwali Formation, Narmia Nala, Surghar Range, West Pakistan.

Repository. Figured specimen (Pl. 3, figs. 9, 10) MCZ 9605.

Genus *Stacheites* Kittl, 1903
Type species, *Stacheites prionoides* Kittl, 1903

Stacheites sp. indet.
Plate 3, figure 13

This genus is recognized in the collections from an extremely poorly preserved specimen; were it not for the partial preservation of a very distinctive suture, the specimen never could have been identified. The specimen has an approximate diameter of 29 mm; even though it is crushed it appears to have been a compressed form; the venter is not preserved on any part of the specimen. The umbilicus has a diameter of approximately 5 mm. The suture is shown on Figure 22D. The absence of denticulation is clearly a result of the weathered nature and poor preservation of the specimen; at the same time, I believe the basic outline and pattern of the suture is essentially correct.

Stacheites has now been recorded from a number of localities in Upper Scythian strata. There has long been some confusion surrounding this genus, as Kittl's original figure (1903, p. 27, pl. 4, fig. 8) of the type specimen (*S. prionoides*) was a highly reconstructed drawing with no view of the venter nor any statement in the text as to the character of the venter. The type is a compressed specimen but obviously crushed. The opposite side of the conch is completely missing. The venter is narrow, flattened and sulcate, bordered by acute ventral shoulders. *Stacheites prionoides* is part of the *Tirolites* fauna from the Werfen fauna of Muć, Dalmatia.

Among the species of *Stacheites* that I recognized as valid, the type species is morphologically most similar to a species (in manuscript) from the Tobin Formation of Nevada. The American species is quite similar in the shape of the conch, degree of inflation of the whorls, involution, and suture; the shell, however, has sigmoidal ribs on the flank. The fauna from the Tobin Formation contains *Subcolumbites*, *Ussuri-*

tes, *Arnautoceltites*, and *Isculitoides*, among others, all genera characteristic of the Upper Scythian.

The *Subcolumbites* fauna of Kwangsi, China, contains one species of *Stacheites*—S. *latilobatum* (Chao, 1959). This is a valid species of the genus.

Astakhova (1960a, b) records *Stacheites prionoides* Kittl from the highest Scythian beds on the Mangyshlak Peninsula. Unfortunately, she did not describe nor illustrate her specimens. The associated species include *Arnautoceltites bajarunasi* (Astakhova) and *Leiophyllites radians* (Astakhova).

The Pakistan specimen recorded here cannot be closely compared in terms of conch form with any of the recognized species of *Stacheites* because of its poor preservation. The suture, however, even though it is weathered, does show a marked similarity in basic plan to that of other species of *Stacheites*.

Occurrence. The single specimen came from a five foot limestone bed 38 feet above the base of the Narmia Member (bed no. 32) of the Mianwali Formation, Narmia Nala, Surghar Range, West Pakistan.

Repository. Figured specimen (Pl. 3, fig. 13) MCZ 9609.

Genus *Nordophiceras* Popov, 1961
Type species, *Ceratites euomphalus* Keyserling, 1845

Nordophiceras planorbis (Waagen), 1895
Plate 4, figures 1–3

Lecanites planorbis Waagen, 1895, p. 278, pl. 39, fig. 3.
Meekoceras (*Gyronites*) *planorbis*, -Diener, 1915, p. 197.

This is another of the many species that Waagen (1895) established on a single specimen. His illustration of the specimen is highly idealized and a photograph of the type is shown on Plate 4, figure 1. The specimen is a cast, in sandstone, with one side buried in matrix. The conch is evolute with compressed, somewhat oval whorls. The venter is rounded, and the umbilical shoulder is well rounded. The specimen measures 54 mm in diameter, 19 mm for the height of the adoral whorl, and 18.8 mm for the width of the umbilicus. The few adoral sutures are clearly exposed and can be seen in the photograph. Waagen concluded that the two lateral lobes were without any denticulation and that there was a straight auxiliary series. The region of the umbilical shoulder is so weathered that all features there are blurred and this accounts for the nature of the suture at that place. As for the rest of the suture the basic shape of the first and second lobes and saddles is probably essentially correct, but the absence of denticulation of the lobes is, on my inspection of the specimen, due clearly to weathering.

In addition to Waagen's type specimen I have three specimens collected from the same horizon and locality as Waagen's type. Unfortunately, none of these specimens are as well preserved as Waagen's type and they expose nothing but highly weathered sutures. The best preserved of these specimens (Pl. 4, figs. 2, 3) is about the same size as the type and is identical with the type specimen in all essential features.

Recognition of the genus *Nordophiceras* has aided greatly in our interpretation of late Scythian faunas. The genus includes a number of species previously included in *Meekoceras*, *Ophiceras*, *Prionolobus*, and *Xenodiscus* among others; all are genera thought to be confined to the lower half of the Scythian. Popov (1961, p. 39) included in his new genus *Nordophiceras*, besides the type species, *Xenodiscus karpinskii* (Mojsisovics, 1886), *Xenodiscus schmidti* Mojsisovics, *Xenodiscus dentosus* Mojsisovics, *Xenodiscus euomphalus* Mojsisovics, and *Nordophiceras alexeevae* Popov. Of these species, *X. schmidti* and *X. dentosus* are quite different from the type species, *X. karpinskii*, and are more properly species of *Svalbardiceras* Spath; also *X. karpinskii* cannot be separated from *X. euomphalus* which is an older species name. Thus, of these Siberian species, only two are valid species of *Nor-*

dophiceras, the type—*N. euomphalus*—and *N. alexeevae*. These two species, according to Popov (1961), are confined to his *Dieneroceras* Zone. They differ in that *N. euomphalus* is smooth, and *N. alexeevae* has prosiradiate ribs on the inner whorls. *Nordophiceras euomphalus* is quite similar to *N. planorbis* in its basic conch architecture. There is a remarkable parallelism of these two Siberian species with two species from the *Columbites* fauna of southeastern Idaho, namely *Prionolobus jacksoni* Hyatt and Smith (1905, p. 151, pl. 62, figs. 11–21) and *Meekoceras pilatum* Hyatt and Smith (1905, p. 155, pl. 63, figs. 3–9). *Prionolobus jacksoni* is very similar to *Nordophiceras euomphalus* and perhaps even conspecific. The extremely small sample of *N. euomphalus* prevents conclusive analysis of this relationship. *Meekoceras pilatum*, on the other hand, is an ornamental species of *Nordophiceras* on the same pattern as *N. alexeevae*. The close relationship of these species is part of the reason I believe the north Siberian fauna, that Popov assigns to his *Dieneroceras* Zone, is *Columbites* Zone in age, and not equivalent to the *Anasibirites* Zone as advocated by Popov. These species are older by at least one zone from what I believe to be the age of *N. planorbis*.

There is one other Siberian species that has at least a superficial similarity to *N. planorbis* and this is *Arctoceras simplex* (Mojsisovics) in Popov (1961, p. 67, pl. 17, fig. 1). I fail to find any justification for this identification. The Spitsbergen specimens of *Arctoceras simplex* described by Mojsisovics are inner whorls of *Arctoceras blomstrandi* (Lindström), and of mid-Scythian (*Meekoceras* Zone) age (Kummel, 1961). Popov's specimen is from the *Olenekites* Zone. It appears to be a valid species of *Nordophiceras* and is quite similar in conch form, etc., to *N. planorbis*. Popov (1961, p. 68) states that there are sparse radial ribs disappearing on the body chamber on his species; this feature is not apparent, however, on the illustration of the species.

Occurrence. Waagen's type specimen and the three specimens recorded here came from sandstone beds of the Narmia Member above the hard "Bivalve limestone" on the east side of Chhidru Nala, Salt Range, West Pakistan.

Repository. Holotype (Pl. 4, fig. 1) GSI 7226; topotype (Pl. 4, figs. 2, 3) MCZ 9611; unfigured topotypes MCZ 9612.

Nordophiceras cf. *planorbis* (Waagen), 1895
Plate 4, figures 4, 5

Two specimens were collected from the Narmia Member in the Surghar Range which are possibly conspecific with the specimens of *Nordophiceras planorbis* from this member at Chhidru in the Salt Range. However, the poor preservation of these specimens and differences in morphological appearance suggest separate treatment for the time being at least. The main apparent differences are a slightly greater degree of evolution of the conch, more compressed whorls, and less distinct umbilical shoulders. The suture is shown on Figure 22B. All of these features, though, are affected to a greater or lesser degree by the state of preservation.

Occurrence. The specimen illustrated on Plate 4, figure 4, came from a 10 foot bed of limestone, 17 feet above the base of the Narmia Member (bed no. 30) in Narmia Nala, and the specimen shown on Plate 4, figure 5, came from a 7 foot bed of limestone 40 feet above the base of the Narmia Member (bed no. 9), Landa Nala, Surghar Range, West Pakistan.

Repository. MCZ 9613 (Pl. 4, fig. 4), MCZ 9614 (Pl. 4, fig. 5).

Genus *Arctomeekoceras* Popov, 1962
Type species, *Meekoceras rotundatum* Mojsisovics, 1886

Arctomeekoceras sp. indet.
Plate 2, figures 1–5

This species is represented by the largest number of specimens collected from the

Narmia Member of the Mianwali Formation. The preservation in most cases is much poorer than that of the other species in the fauna. Morphologically, this species is not very distinctive making identification difficult and perhaps even tenuous. The conch is compressed and involute. The venter is narrowly rounded on the younger whorls and appears to become more broadly rounded during growth, reflecting a slight inflation of the whorls. The ventral shoulders in either stage are rounded. The umbilical shoulder, however, is abruptly rounded and the umbilical wall is vertical. No surface markings, as growth lines, etc., are present on any of the specimens. The suture is shown on Figure 22E.

There are no species in the late Scythian faunas of Tethys, as for instance of Albania, Chios, or Timor, that bear any resemblance to this Pakistan species. It is within the *Olenekites* fauna of northern Siberia where one can recognize morphologically similar forms. Mojsisovics (1886) first described from the Olenek fauna a number of species which he placed in the genera *Meekoceras* and *Xenodiscus*. These are an interesting assemblage of species that most Triassic students have had difficulty in interpreting. Very few comparable species types have turned up in other late Scythian deposits. Spath (1934) suggested that several of these species probably represented new and distinct generic groups but refrained from any further action. It is through the publications of Yu. N. Popov (1961, 1962a) that we have much new data on the Olenek fauna. From among the original group of species which Mojsisovics assigned to *Meekoceras* and *Xenodiscus*, Popov has introduced three new generic names. These are: *Boreomeekoceras* Popov (1961, p. 41)—type species *Meekoceras keyserlingi* Mojsisovics (1886, p. 81, pl. 10, fig. 11), *Nordophiceras* Popov (1961, p. 38)—type species *Xenodiscus karpinskii* Mojsisovics (1886, p. 75, pl. 11, fig. 13), and *Arctomeekoceras* Popov (1962a, p. 186, pl. 1, figs. 1, 5)—type species *Meekoceras rotundatum* Mojsisovics (1886, p. 83, pl 10, fig. 16). Within his genus *Nordophiceras*, Popov included a heterogenous group of species; those species allied to the type species with rounded venters are confined to Popov's *Dieneroceras* Zone. The flat ventered species (e.g. *X. schmidti*) are confined to the *Olenekites* Zone and should be placed in *Svalbardiceras*. *Boreomeekoceras* is characterized by forms with involute compressed conchs, narrowly rounded venter, and a suture with a long serrated auxiliary series. *Arctomeekoceras* is likewise an involute, compressed form but the venter is broader, the umbilical shoulder more sharply rounded, and the suture with a short auxiliary series. In the Siberian region *Arctomeekoceras* is known only from the *Olenekites* Zone.

All of these arctic species are as yet known by relatively few specimens and there is no question but much more data is needed. The Pakistan specimens recorded here are more similar to *Arctomeekoceras rotundatum* than to any other species of late Scythian ammonoid. The incompleteness of the sample and general poor preservation prevent a more detailed analysis.

Occurrence. This species has been collected from three localities in the Narmia Member of the Mianwali Formation: (1) from a 3.5 foot bed of limestone 20 feet above the base of the Narmia Member (bed no. 5) in Landa Nala, Surghar Range; (2) from a 10 foot bed of limestone 18 feet above the base of the Narmia Member (bed no. 30) in Narmia Nala, Surghar Range; and (3) from an 8 foot bed of limestone 126 feet above the base of the Narmia Member (bed no. 34) in Nammal Gorge, Salt Range, West Pakistan.

Repository. Figured specimens (Pl. 2, figs. 1, 2) MCZ 9584, (Pl. 2, figs. 3, 4) MCZ 9585, (Pl. 2, fig. 5) MCZ 9586; unfigured specimens from Landa Nala MCZ 9590, 9592, from Narmia Nala MCZ 9589, from Nammal Gorge MCZ 9591.

Family TIROLITIDAE Mojsisovics, 1882
Genus *Tirolites* Mojsisovics, 1879
Type species, *Tirolites idrianus* Hauer, 1865

Tirolites sp. indet.
Plate 4, figures 8, 9

The collections contain a single specimen that in spite of its poor preservation can be assigned to the genus *Tirolites*. The conch is evolute with subrectangular whorl sections. The venter is broad, very low arched. Along the ventral shoulder are nodes that clearly are extensions of ribs. Unfortunately, the whorl sides from the mid section to the umbilical seam are not at all well preserved, but there is faint indication that these ribs extend across much of the flank. Of the suture only the first lateral saddle is visible, and this lies across the ventral shoulder.

Tirolites is the principal genus of the Alpine Werfen fauna. It has been traditional to place the *Tirolites* fauna between the *Owenites* Zone and the *Columbites* Zone in our Scythian chronological scheme. The genus, however, has been recorded from several upper Scythian faunas. For instance, it is present in the *Columbites* fauna of southeastern Idaho (Smith, 1932), the *Ussurites* fauna in the Confusion Range, Utah (Silberling, *in* Hose and Repenning, 1959, p. 2189), and the *Subcolumbites* fauna of Albania (Arthaber, 1911). The biology and stratigraphic range and significance of the genus is in need of a thorough revision.

Occurrence. From micaceous sandstone bed 17 feet above base of Narmia Member (bed no. 29) of Mianwali Formation, Nammal Gorge, Salt Range, West Pakistan.

Repository. Figured specimen (Pl. 4, figs. 8, 9) MCZ 9615.

Family HUNGARITIDAE Waagen, 1895
Genus *Prohungarites* Spath, 1934
Type species, *Prohungarites similis* Spath, 1934

Prohungarites cf. *crasseplicatus* (Welter), 1922
Plate 3, figures 11, 12

Hungarites crasseplicatus Welter, 1922, p. 147, pl. 168(14), figs. 1–6.
Prohungarites crasseplicatus, -Spath, 1934, p. 244; Spath, 1951, p. 20; Kummel, 1961, p. 525.
Hungarites cf. *middlemissii* Diener, *in* Welter, 1922, p. 146, pl. 13, figs. 6–9, 18.
Prohungarites similis Spath, 1934, p. 327; Spath, 1951, p. 19; Kummel, *in* Arkell et al., 1957, p. L155, fig. 187, 6.

Four small phragmocones of fair preservation from the Narmia Member exposed at its type locality in Narmia Nala are in the collections. The better preserved of the four specimens (Pl. 3, figs. 11, 12) measures approximately 30.5 mm in diameter, 11.3 mm for the width of the adoral whorl, 12.8 mm for the height of the whorl, and 8.5 mm for the diameter of the umbilicus. The conch is fairly evolute with compressed whorls. The whorl flanks are flattened and converge slightly toward the venter. The venter is low and broadly rounded as are the ventral shoulders. The umbilical shoulders are more sharply rounded and the umbilical wall is vertical. The whorl flanks bear low, broad radial ribs that extend from the umbilical to the ventral shoulders. On the inner volutions, at a diameter of 8 mm, the venter is acute and the whorl sides broadly convex. The suture (Fig. 22C) consists of a broad, prominent first lateral lobe, a much smaller second lateral lobe and a very small auxiliary lobe on and just above the umbilical shoulder.

Spath (1934, p. 327) introduced the generic name *Prohungarites* for *P. similis* Spath (= *Hungarites* cf. *middlemissii* Welter (non Diener) 1922). This species along with *Hungarites crasseplicatus* Welter (1922) comprise an interesting keeled group of ammonoids from the blocks with the manganese coated fossils at Nifoekoko, Timor. These two species were originally separated merely on differences in the intensity of the ribbing. Even Welter (1922, p. 147) discussed the gradational aspects of these species and illustrated one specimen (Welter, 1922, pl. 167 (13), figs. 10, 11) as a transitional form between *Hungarites* cf. *middle-*

missii and *Hungarites crasseplicatus.* Restudy of Welter types shows that his descriptions and illustrations of these species are quite adequate. There appears no doubt but that these two species are synonymous. I would also place in the synonymy of *P. crasseplicatus* the specimen Kiparisova (1961, p. 160, pl. 31, fig. 5) described as *Prohungarites* (?) *popovi* from an horizon she characterized as the end of the Olenek stage (Upper Scythian) or the beginning of the Anisian.

The Pakistan specimen recorded here differs from the Timor *P. crasseplicatus* principally in the absence of any indication of a keel along the central part of the venter on the mature whorls. In all other conch features, such as shape of the whorl section, shape of the ventral and umbilical shoulders, and nature of the umbilical wall, it is very similar. The suture is likewise essentially the same. The other Timor species of *Prohungarites*, *P. tuberculatus* (Welter), is more robust with a more highly developed ornamental pattern.

There is a stronger morphological similarity to a species from the upper Thaynes Formation of southeastern Idaho that I have previously recorded as *Prohungarites* n. sp. cf. *P. crasseplicatus* Welter (Kummel, 1954, p. 187). This species will be fully documented in another publication. It is very similar to the Pakistan species in most essential features. Whereas I believe the Pakistan and Idaho forms are distinct species, at the same time they are extremely closely related. Both species have acute venters only on the earliest volutions and rounded venters on the later volutions. It is mainly in this feature that these two species are distinct from *P. crasseplicatus* from Timor.

Occurrence. The four specimens came from a 10 foot limestone bed, 17 feet above the base of the Narmia Member (bed no. 30) of the Mianwali Formation in Narmia Nala, Surghar Range, West Pakistan.

Repository. Figured specimen (Pl. 3, figs. 11, 12) MCZ 9606, unfigured specimen MCZ 9607.

APPENDIX

Stratigraphic section of Triassic Formation exposed on north side of small creek 200 yards east of road, one-quarter mile southeast of Kathwai, Salt Range, West Pakistan (Figs. 6, 7).

Bed No.		Thickness Feet
MIANWALI FORMATION (Lower Triassic)		
Mittiwali Member		
7.	Shale, olive-gray, mostly covered	30.0
6.	Limestone, gray, fine-grained, coquinoidal, thin-bedded, slightly glauconitic, poorly preserved ammonites (*Gyronites*, etc.)	5.9
	Total	35.9
Kathwai Member		
5.	Limestone, tan and gray, fine-grained, faintly glauconitic; contains brachiopods and echinoderm fragments	1.0
4.	Limestone, yellow-brown, thin-bedded, soft, coquinoidal, contains ammonites (*Ophiceras*), *Orbiculoidea*, rhynchonellid brachiopods, echinoid spines, crinoid fragments; most fossils come from six inch bed one foot from top of unit	5.0
3.	Limestone, yellow-brown, highly dolomitic, echinodermal, massive, weathers rust brown	1.0
2.	Dolomite, like unit 1 but in beds one to two inches thick	2.9
1.	Dolomite, yellow-brown, massive, fine-grained, weathers rust brown,	

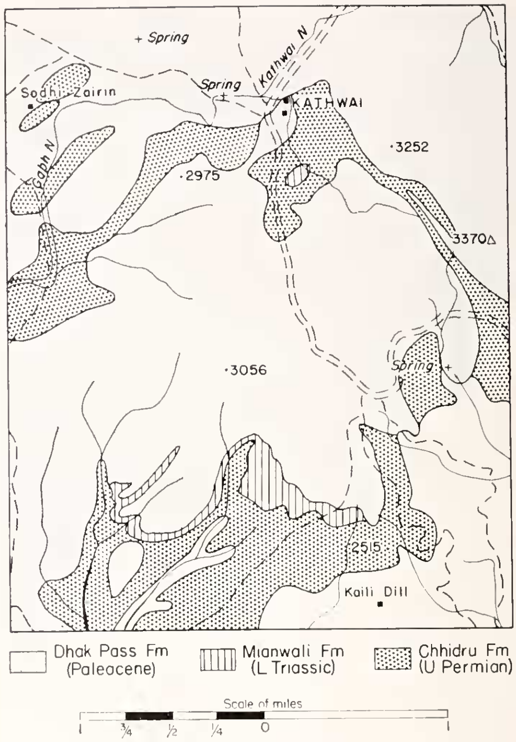

Figure 6. Locality map of Kathwai region, Salt Range, West Pakistan showing distribution of late Permian and Triassic formations. Geologic data from unpublished map by E. R. Gee.

Figure 7. Unnamed nala two miles south of Kathwai, Salt Range, West Pakistan. The bench in the mid-part of the photograph is formed by the Kathwai Member and the "Lower Ceratite limestone" of the Mianwali Formation.

contains *Glyptophiceras, Orbiculoidea,* large smooth pectins; fossils come from upper six inches of unit 2.6

Total 12.5

Total Mianwali Formation 48.4

CHHIDRU FORMATION (Upper Permian)

00. Sandstone, white, soft, weathers yellow 2.6-0
0. Limestone, gray, sandy, massive, with abundant Permian fossils; on west side of nala, fifty yards off this unit immediately underlies unit 1 and the white friable sandstone is absent

Stratigraphic section of Triassic formations exposed 1.5 miles southeast of Kufri, 0.5 miles north of highway marker 31 on road from Kuraddi to Kathwai (Figs. 8, 9).

Bed No. Thickness Feet

MIANWALI FORMATION (Lower Triassic)

Narmia Member

12. Limestone, light gray, fine-grained,

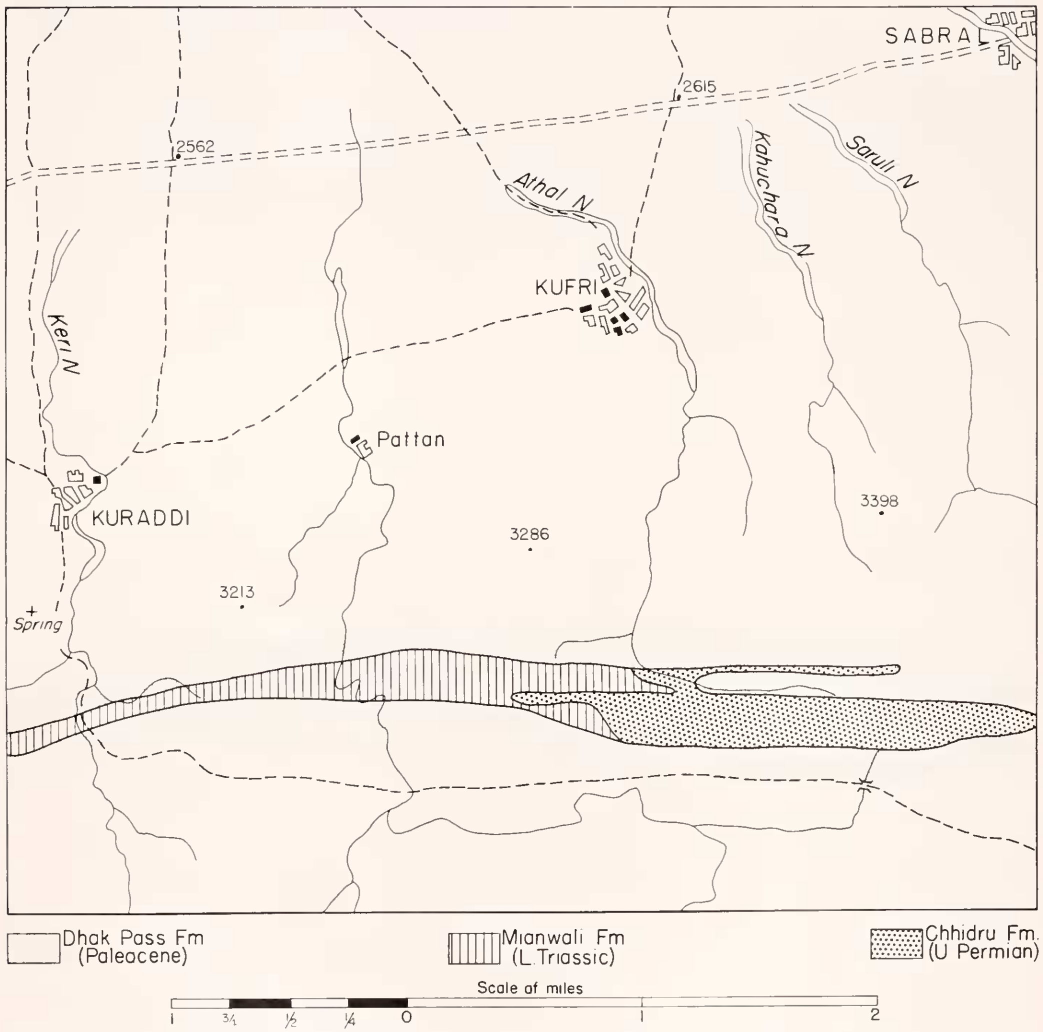

Figure 8. Locality map of Kufri region, Salt Range, West Pakistan, showing distribution of late Permian and Triassic formations. Geologic data from unpublished map by E. R. Gee.

Figure 9. The Kufri locality in the Salt Range of West Pakistan. The hills in the right half of the photograph are made up of the Chhidru Formation; the dip slope of these hills is held up by the Kathwai Member and the "Lower Ceratite limestone"; the saddle is underlain by the "Ceratite marls" and the following slope the "Ceratite sandstone" and the "Upper Ceratite limestone"; the face of this ridge is formed by the "Bivalve limestone" of the Narmia Member and this is overlain by the Dhok Pass Formation of Paleocene age.

very hard, massive, a coquina of pelecypods. This is the Bivalve limestone of Waagen; here overlain by Eocene limestones	10.0
Total 10.0	
Mittiwali Member	
11. Sandstone, iron-brown, massive, hard, has traces of poorly preserved pelecypods	4.0
10. Covered, probably shale	6.0
9. Limestone like bed 8, in beds one foot thick, separated by shale interbeds; contains ammonites (*Stephanites* and *Anasibirites*)	25.0
8. Limestone, gray, fine-grained, sandy, hard, in beds 4–6 inches thick, separated by one inch beds of tan, silty shale, also a few beds of tan fine-grained sandstone; contains many poorly preserved ammonites	30.0
7. Covered, interval includes much of the Ceratite marls and the Ceratite sandstone	115.0
6. Shale, olive-gray, with 4–6 inch beds of hard, argillaceous, olive limestone, fossiliferous	20.0
5. Limestone, gray, thin-bedded; contains numerous poorly preserved ammonites	4.0
Total 204.0	
Kathwai Member	
4. Limestone, gray, thin-bedded, with an occasional poorly preserved ammonite (*Ophiceras*?) and *Orbiculoidea*	1.5
3. Dolomite, gray-brown, massive, hard, weathers brown; contains cidarid spines and small brachiopods	1.0
2. Dolomite as unit 1 but thinner bedded; contains rhynchonellid brachiopods, fish teeth, crinoid fragments, and fucoids	3.0
1. Dolomite, yellow-brown, sandy, weathers brown; contains poorly preserved pelecypods	10.0
Total 15.5	
Total Mianwali Formation 229.5	
CHHIDRU FORMATION (Upper Permian)	
00. Sandstone, white, friable, massive, with crinoid remains and shell fragments	2.0
0. Limestone, gray, sandy, massive, with *Bellerophon*	2.0

Stratigraphic section of basal part of the Triassic Mianwali Formation exposed in Munta Nala, west of Wargal, Salt Range, West Pakistan (Figs. 10–13).

Bed No.		Thickness (in feet)
MIANWALI FORMATION (Lower Triassic)		
Mittiwali Member (lower part)		
16.	Limestone, gray, fine- to medium-grained; very fossiliferous, with small pectinid pelecypods, ammonoids (*Gyronites*, etc.) and fish remains	1.0
15.	Shale, gray	0.8
14.	Limestone, yellow-gray, thin-bedded; with numerous ammonoids (*Gyronites*, etc.)	1.9
13.	Limestone, light-gray, dense, hard, glauconitic, weathers brown	0.2
12.	Limestone, very light gray, irregular texture, contains large pelecypods, fragments of ammonites, fish teeth	1.4
Kathwai Member		
11.	Sandstone, gray, massive, with a few one-inch calcareous beds	3.0
10.	Limestone, pinkish-gray, fine-grained; unit begins with four inches of grayish-black shale, followed by three inches of lenticular limestone, then one foot of laminated to thin-bedded sandstone, then limestone; contains small pectinids, ammonoids (*Ophiceras*?), and fish teeth	2.5
9.	Dolomite, light gray, massive, weathers iron-brown; contains shell fragments, rhynchonellid brachiopods, eumorphotid pelecypods, ammonites (*Ophiceras*?), cidarid spines, fish teeth	2.4
8.	Shale, dark gray, with laminae of fine, tan sandstone, contains poorly preserved brachiopods, *Campylites*?, and pelecypods	1.5

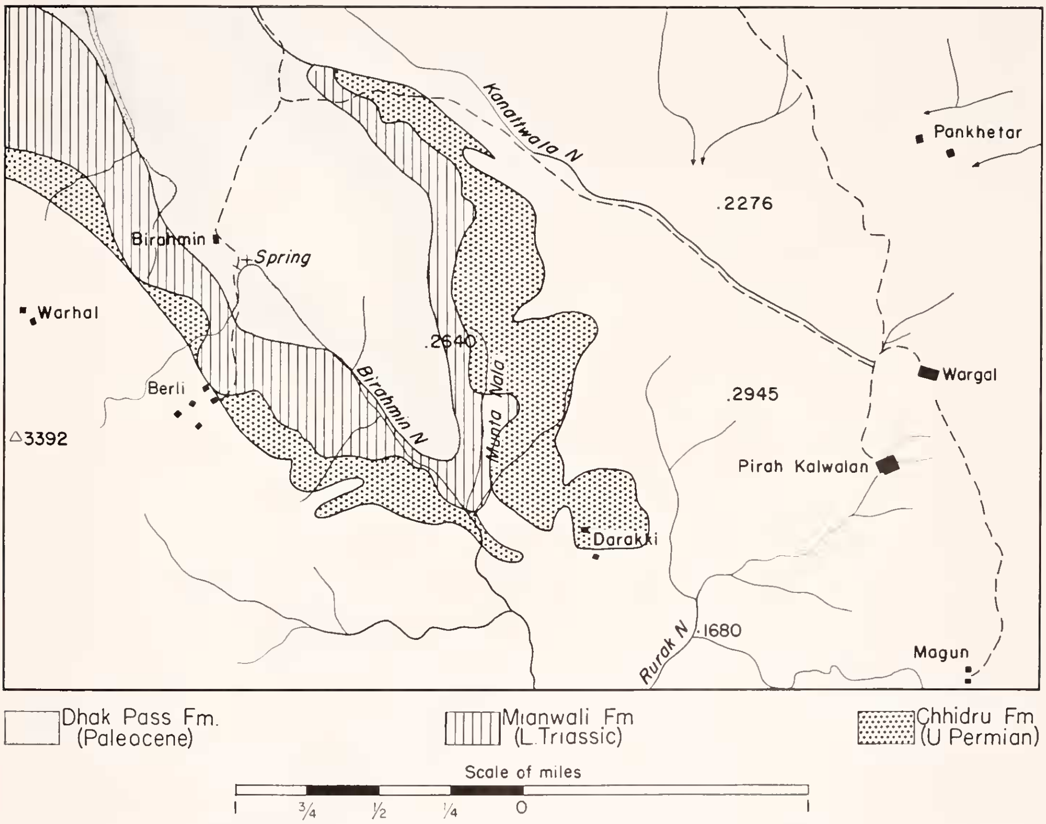

Figure 10. Locality map of Munta Nala (Wargal region), Salt Range, West Pakistan showing distribution of later Permian and Triassic formations. Geologic data from unpublished map by E. R. Gee.

Figure 11. Permian and Triassic formations exposed along Munta Nala, Wargal region, West Pakistan. The dip slope to the right of the nala is formed by the Chhidru Formation; the strata to the left of the nala are the Mianwali Formation.

7. Dolomite, tan, fine-grained, massive, upper one foot laminated, weathers brown — 6.0

Total 15.4

CHHIDRU FORMATION (Upper Permian)

6. Shale, dark gray, micaceous, with thin beds of cross-bedded sandstone and laminae of sandstone — 5.9
5. Sandstone, white, massive, friable, lenticular, bed ranges in thickness from two inches to one foot — 1.0
4. Shale, dark gray, clay, with laminae of fine sandstone and thin beds of micaceous sandstone; contains plant fragments — 3.0
3. Sandstone, yellowish gray, calcareous, massive, weathers tan, unit lenticular ranging in thickness from four inches to three feet, contains *Bellerophon* and other typical Permian fossils — 3.0
2. Shale, dark gray, clay, micaceous, with laminae of fine-grained, very pale orange sandstone and one inch to one foot beds of cross-bedded sandstone; contains spectacular slump structures and plant fragments — 6.0
1. Sandstone, very light gray, massive, calcareous, with numerous pockets of typical Permian fossils and worm borings — 4.0

Stratigraphic section of Triassic formations exposed on the west side of Chhidru Nala, Salt Range, West Pakistan (Figs. 14, 15).

Bed No. — Thickness Feet

MURREE FORMATION (Miocene)

Sandstone, variegated

MIANWALI FORMATION (Lower Triassic)

Narmia Member

26. Dolomite, red and yellow-brown, medium grained, massive, unit hard and a ridge former — 10.0
25. Sandstone, pink and violet toward base, remainder white, calcareous, fine-grained, massive, soft, friable, a few two foot beds of shale — 37.0
24. Shale, gray and olive, with siltstone, unit poorly exposed — 23.0

Figure 12. The Permo-Triassic contact beds along Munta Nala near Wargal, Salt Range, West Pakistan. The shaly beds at the bottom of the ledge are part of the white sandstone unit of the Chhidru Formation and the overlying massive strata are the dolomite beds of the Kathwai Member.

Figure 13. Mianwali Formation exposed in Munta Nala. Uppermost hard layer is Dhak Pass Formation of Paleocene age.

23. Sandstone, tan to rust-brown, some thin red units, calcareous, thin evenly bedded, micaceous, unit soft, not well exposed, probably includes beds of sandy shale or shaly sandstone; contains ammonites (*Xenoceltites sinuatus*, *Nordophiceras planorbis*) and orthocerids 40.0
22. Limestone, light gray, very hard, massive, weathers rusty-gray, a coquina of pelecypods for the most part, also contains poorly preserved ammonites, upper six inches of unit contains numerous nautiloids including *Enoploceras* and orthocerids 5.0
21. Sandstone, yellow-brown, a coquina of pelecypods; this unit plus unit 22 make up the Bivalve bed of Waagen 3.5

Total 118.5

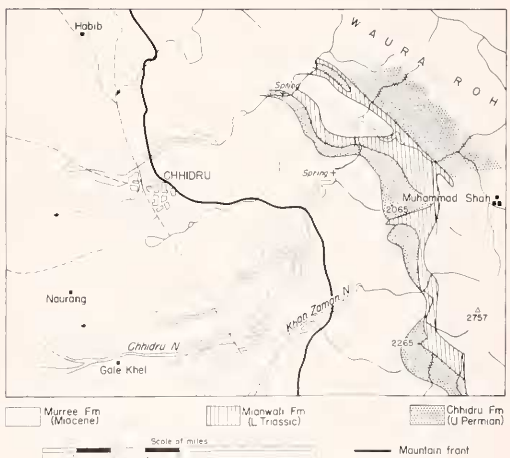

Figure 14. Locality map of Chhidru Nala, Salt Range, West Pakistan, showing distribution of late Permian and Triassic formations. Geologic data from unpublished map by E. R. Gee.

Figure 15. Triassic Formation on east side of Chhidru Nala, Salt Range, West Pakistan. The hard units forming the crest of the ridge are the "Upper Ceratite limestone." The uppermost of these hard beds is the "Bivalve limestone" and the following slope is made up of shale and sandstone beds of the Narmia Member.

Mittiwali Member	
20. Sandstone like bed 19, but very thinly bedded, no fossils seen	2.5
19. Sandstone, yellow-brown, fine-grained, massive; contains poorly preserved ammonites	2.5
18. Sandstone, gray and tan, fine-grained, in thin beds, with numerous beds of gray limestone which contain ammonites	33.0
17. Limestone, gray, thin- to medium-bedded, some beds of sandstone, unit very fossiliferous, but preservation poor	47.0
16. Sandstone, gray, tan, massive to thin-bedded, mostly covered	45.0
15. Shale, black to olive, with numerous thin beds of micaceous sandstone and argillaceous limestone, fossiliferous	125.0
14. Limestone, gray, hard, very fossiliferous, *Gyronites*, etc.	1.6
13. Shale, black, with thin beds of fine-grained, tan sandstone, mostly covered	3.0
12. Limestone, gray, fine-grained, hard, thin- to medium-bedded, very fossiliferous, *Gyronites*, etc., but preservation poor	3.0
Total 262.6	
Kathwai Member	
11. Sandstone, tan, fine-grained, laminated	0.2
10. Limestone, gray, coquinoidal, consisting of pelecypods, brachiopods, and gastropod fragments; contains fairly well preserved ammonites and pelecypods	0.9
9. Limestone, grayish-tan, fine-grained, thin-bedded, scoured in part, dolomitic, with minor amounts of glauconite	2.0
8. Sandstone, grayish-tan, fine-grained, thin-bedded, with 2 inch bed of limestone in center containing *Ophiceras connectens*	2.5
7. Limestone, light gray, hard, fragmental; contains rhynchonellids and ammonites (*Ophiceras*)	1.0
6. Shale, olive-gray, with some thin sandstone beds	1.0

5. Limestone, gray, hard, contains brachiopods, crinoid remains, ciderid spines, teeth and bone fragments — 1.0
4. Dolomite like bed 3, but harder; contains fossil fragments — 1.3
3. Dolomite, tan, fine-grained, thin-bedded, shaly, unit soft — 0.8
2. Dolomite, tan, medium to massively bedded, sandy in lower part; contains fossil fragments — 2.5
1. Dolomite, tan, mottled, sandy, hard, massive — 3.6

Total 16.8

Total Mianwali Formation 397.9

CHHIDRU FORMATION (Upper Permian)

00. Sandstone, white, fine-grained, friable, with echinoderm fragments and poorly preserved pelecypods — 12.0
0. Limestone, gray, sandy, with abundant bellerophons, productids, and other typical Permian forms

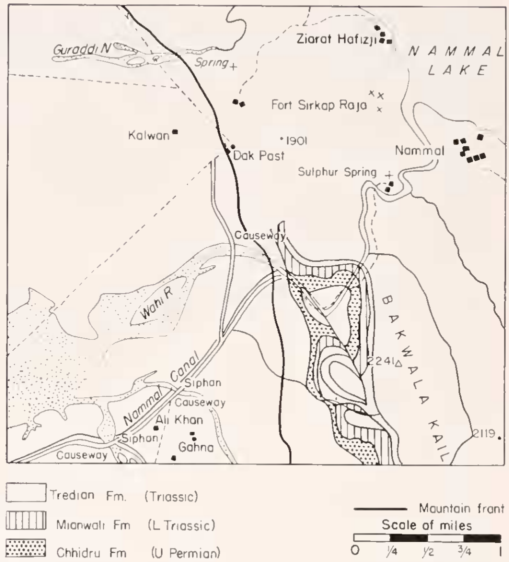

Figure 16. Locality map of Nammal Gorge, Salt Range, West Pakistan showing distribution of late Permian and Triassic formations. Geologic data from unpublished map by E. R. Gee.

Stratigraphic section of Triassic formations exposed in Nammal Gorge, Salt Range, West Pakistan (Figs. 16, 17, 18).

Bed No. — Thickness Feet

TREDIAN FORMATION (?Lower and ?Middle Triassic)

Khatkiara Member

44. Sandstone, white, massive

Landa Member

43. Sandstone, tan to red, thin-bedded to massive, parts laminated, contains ripple marks and abundant slump structures — 28.0
42. Sandstone, tan, red in part, massive, cross-bedded, alternating with sandy, micaceous shale containing plant fragments — 8.0
41. Shale like bed 39 but with fewer and thinner hard beds — 27.0

Total 63.0

MIANWALI FORMATION (Lower Triassic)

Narmia Member

40. Dolomite, gray, sandy in part, massive, weathers rust-brown, one incomplete and poorly preserved ammonite collected — 5.0
39. Shale, gray and black, with several one-foot beds of gray, sandy limestone that weather rust-brown — 22.0
38. Sandstone, pink, massive, in part laminated, weathers rust-brown, no fossils seen — 4.0
37. Shale like bed 35 — 6.0
36. Limestone like bed 34; contains orthocerids, abundant crinoid fragments and worm tracks — 6.0
35. Shale, gray-black, silty, with thin beds of laminated calcareous sandstone and 2–6 inch beds of gray limestone; top of unit is one-foot bed of massive sandstone with slump structures; unit contains poorly preserved ammonites and pelecypods — 12.5
34. Limestone, gray, very hard, sandy in part, irregularly bedded in part, glauconitic in part; contains poorly preserved ammonites (*Pseudosageceras multilobatum*, *Arctomeekoceras* sp. indet., *Svalbardiceras* sp. indet.), pelecypods, and brachiopods — 8.0
33. Shale and sandstone like bed 31, sandstone in part pink — 30.0
32. Sandstone, tan, massive, cross-bedded in part, a few thin beds of sandy limestone containing abundant small, poorly preserved pelecypods, a few 6 inch shale beds present — 7.5
31. Shale, gray-black, in beds 1–2 feet thick, alternating with tan sandstone showing slump structures — 22.0

Figure 17. Mianwali Formation in Nammal Gorge, Salt Range, West Pakistan. The white strata in the lower left-hand corner of the photograph are the upper beds of the Chhidru Formation, the overlying massive beds are the Kathwai Member and the "Lower Ceratite limestone"; then come the "Ceratite marls"; the next massive beds are the "Ceratite sandstone," and the uppermost strata are part of the "Upper Ceratite limestone."

30. Sandstone, tan, fine- to medium-grained, massive — 6.5
29. Shale, gray-black, with a few beds of tan, slightly pink, micaceous sandstone and sandy gray limestone, pelecypods and ammonites (*Tirolites* sp. indet.) present but poorly preserved — 53.0
28. Limestone, dark to light gray, massive, very hard, coquinoid beds of pelecypods alternate with irregularly bedded limestones that contain brachiopods, ammonites, pelecypods, and gastropods. This unit is intermediate in its lithology between the typical Bivalve bed as seen in Chhidru and the basal limestone beds at Narmia. — 7.0

Total 189.5

Mittiwali Member

27. Sandstone, tan, calcareous, fine-grained, thin-bedded, with thin beds of black shale and gray limestone — 2.5
26. Limestone, gray, massive, very hard — 2.0
25. Limestone, dark gray, in beds 1–4 inches thick alternating with 1–4 inch beds of black, micaceous shale and siltstone; contains ammonites (*Anasibirites*) — 23.0
24. Limestone, gray, fine-grained, in beds 1–3 inches thick; contains numerous poorly preserved ammonites — 16.0
23. Sandstone, tan, fine-grained, thin-bedded, with a few thin interbeds of shale and gray limestone — 3.0
22. Limestone, gray, fine-grained; contains poorly preserved ammonites — 4.0
21. Sandstone like bed 20 but amount of shale greater, individual beds thinner, a few beds of gray limestone — 10.0
20. Sandstone, gray, micaceous, fine-grained, some beds grade into gray limestone along strike, numerous interbeds of gray shale — 8.6
19. Shale, black and gray, silty, micaceous, with numerous 1–2 inch beds of fine-grained sandstone — 4.5
18. Sandstone, tan and gray, fine-grained, with numerous thin, silty shale interbeds; contains poorly preserved ammonites — 4.6
17. Siltstone, tan, massive, with some gray limestone — 4.0
16. Shale, black, micaceous, with thin laminae of black siltstone and lenticular beds of fine-grained sandstone — 3.2
15. Siltstone, gray-black, micaceous, thin-bedded, laminated — 3.0
14. Sandstone, tan and gray, calcareous, hard, massive, laminated, with ripple marks — 2.3
13. Shale, as bed 11 but with one 2 inch lenticular bed of gray limestone — 3.5
12. Sandstone, light tan, massive, cross-bedded — 2.2
11. Shale, black, micaceous, alternating with 1–3 inch beds of micaceous, laminated, fine-grained sandstone — 9.0
10. Sandstone like bed 9 in beds approximately one foot thick alternating with beds of laminated shaly sandstone — 4.0
9. Sandstone, tan and gray, fine-grained, massive — 4.0
8. Shale, black, silty, micaceous, with

Figure 18. The Landa Member (lower part of photograph) and Khatkiaro Member of the Tredian Formation exposed in Nammal Gorge, Salt Range, West Pakistan.

thin laminae of siltstone and 6 inch beds of fine-grained, lenticular beds of sandstone	8.5
7. Sandstone, light gray, micaceous, fine-grained, cross-bedded, with some thin shale interbeds	3.0
6. Shale, olive-gray to black, micaceous in part, silty in part, with numerous 1–15 inch beds of hard, lenticular argillaceous and sandy limestone; contains few ammonites and pelecypods	118.0
5. Limestone, gray, fine-grained, in beds 1–3 inches thick; contains abundant poorly preserved ammonites	4.0
Total 246.9	
Kathwai Member	
4. Sandstone, white, thin-bedded, alternating with thin 1–2 inch beds of gray, sandy limestone; contains poorly preserved ammonites (*Ophiceras*) and rhynchonellid brachiopods	2.0
3. Dolomite, gray, sandy, weathers brown, in beds 1–3 inches thick, lower two-thirds of unit contains cidarid spines and crinoid remains, upper part contains small brachiopods	3.0
2. Dolomite as bed 1, contains cidarid spines and crinoid remains	1.4
1. Dolomite, gray, sandy, massive, weathers brown, no fossils seen	4.6
Total 11.0	
Total Mianwali Formation 447.4	
CHHIDRU FORMATION (Upper Permian)	
00. Shale, black, micaceous, with laminae of tan micaceous siltstone	1.5
0. Sandstone, white, massive, friable	2.0

Stratigraphic section of Triassic formations exposed in Zaluch Nala, Salt Range, West Pakistan (Fig. 19).

Bed No.	Thickness Feet
TREDIAN FORMATION (?Lower and ?Middle Triassic)	
Khatkiara Member	
33. Sandstone, white, massive, cross-bedded	
Landa Member	

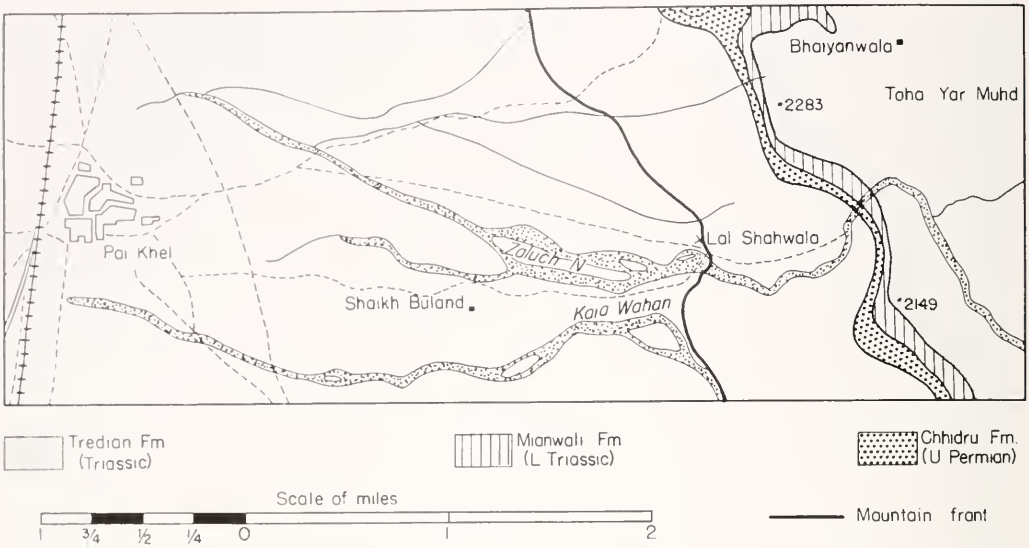

Figure 19. Locality map of Zaluch Nala, Salt Range, West Pakistan, showing distribution of late Permian and Triassic formations. Geologic data from unpublished map by E. R. Gee.

32. Sandstone, a mixture of the types that make up beds 27, 28, and 31, in addition purple and red beds, splendid slump structures in upper part, a few beds of dark gray, brown, silty shale — 20.0
31. Sandstone, white, massive, with 6 inch rust-brown nodules — 2.6
30. Sandstone, like bed 28, reddish in part — 6.0
29. Sandstone like bed 27, massive — 1.6
28. Sandstone, gray-brown, micaceous, massive, laminated — 1.3
27. Sandstone, light gray, massive, laminated, medium-grained, weathers reddish brown — 1.0
26. Shale, dark grayish black, silty, with numerous beds of red-brown, laminated, micaceous sandstone, 1–12 inches thick — 30.0

Total 62.5

MIANWALI FORMATION (Lower Triassic)

Narmia Member

25. Dolomite, rust-brown, partly gray, weathers rust-brown — 2.5
24. Dolomite, gray, very sandy, massive, weathers rust-brown — 2.9
23. Shale, black, with thin beds of laminated, micaceous sandstone — 7.0
22. Dolomite, gray, sandy, micaceous, massive, laminated, weathers rust-brown — 5.0
21. Covered, probably shale — 15.0
20. Shale, gray to black, silty, micaceous, with thin beds of hard, dark gray limestone near base; above this are three beds of reddish brown and gray dolomite 1.5, 1.5, and 4 feet thick respectively; one of these beds yielded an orthocerid cephalopod and two poorly preserved ammonites — 33.0
19. Limestone, gray, fine-grained, very glauconitic in part, very hard, part of unit a coquina of small pelecypods; lithologic character of unit is a combination of that of the Bivalve beds as seen at Chhidru and the basal limestone at Narmia — 10.0

Total 76.4

Mittiwali Member

18. Sandstone, gray, speckled brown, massive — 5.0
17. Sandstone, light to dark gray, massive, finely laminated, micaceous and silty, olive, micaceous shale; 12 feet from top of unit there is an 8 inch bed of very hard, dark gray limestone, mottled rust-brown which yielded one ammonite, one nautiloid, and one rhynchonellid brachiopod — 55.0
16. Shale, gray and black, with thin beds of gray limestone, weathering brown, unit poorly exposed, some

structural disturbance evident; toward middle of unit are two beds of gray sandy limestone and gray calcareous sandstone, pelecypods present, one ammonite found in float 110.0

15. Limestone, light gray, very hard, in beds 1–6 inches thick, weathers gray, with a few thin laminated beds of gray-black siltstone, numerous poorly preserved ammonites 29.0
14. Sandstone and shale in combination as seen in beds 10, 11, and 12, in units of approximately equal thickness; first have mainly light sandstones, then mainly shales, then mainly sandstones, finally mainly shales, a few thin beds of hard, dark gray limestone, two ammonites collected 31.0
13. Shale, dark olive-gray, silty, micaceous, with a few thin beds of fine-grained sandstone 6.5
12. Sandstone, light gray, micaceous, laminated, with a few beds of gray-black shale 6.0
11. Sandstone like unit 10 but in thinner beds alternating with gray-black, micaceous, shaly siltstone and shale 13.0
10. Sandstone, light gray, fine-grained, massive, laminated, appears to be calcareous, with several 4 inch beds of olive, micaceous siltstone 9.5
9. Shale, olive, silty 2.0
8. Siltstone, olive, micaceous, finely laminated in massive beds 1.8
7. Shale, olive, with numerous 1–6 inch beds of gray, argillaceous limestone and thin beds of olive, micaceous siltstone 48.0
6. Limestone, gray, in beds 2–3 inches thick, very fossiliferous, preservation poor 6.0

Total 322.8

Kathwai Member

5. Limestone, gray, glauconitic, fine-grained; contains rhynchonellid brachiopods 1.6
4. Dolomite, gray, glauconitic in upper part, weathers rust-brown 3.0
3. Dolomite, light gray, friable; contains crinoid fragments 2.6
2. Dolomite, light gray, massive, hard, weathers rust-brown; contains crinoid fragments and pelecypods 3.6
1. Dolomite, grayish tan, fine-grained 0.6

Total 11.4

Total Mianwali Formation 410.6

CHHIDRU FORMATION (Upper Permian)

00. Sandstone, grayish white 0.6
0. Limestone with abundant bellerophons

Stratigraphic section of Triassic formations exposed in Narmia Nala, Surghar Range, West Pakistan (Figs. 20, 21).

Bed No. — Thickness Feet

TREDIAN FORMATION (?Lower and ?Middle Triassic)

Khatkiara Member

Sandstone, white, massive (not measured)

Landa Member

40. Shale, black and gray, and massive dark brown to dark gray, micaceous sandstone which contains poorly preserved plant remains 100.0

Total 100.0

MIANWALI FORMATION (Lower Triassic)

Narmia Member

39. Limestone, dark gray, made up of pissolites; a conspicuous hard unit containing *Spiriferina* and other brachiopods 7.0
38. Limestone, gray, sandy, massive, weathers rust-brown, with some thin shale beds 14.0
37. Shale, gray-black, with thin beds of calcareous, fine-grained, ripple-marked sandstone 40.0
36. Limestone, gray, sandy, weathers iron-brown; contains a few ammonites (*Isculitoides* sp. indet., *Subvishnuites* sp. indet.) 2.0
35. Shale, gray-black, with thin beds of sandy dark limestone that weathers brown 22.0
34. Limestone like bed 32, contains ammonites and pelecypods 5.0
33. Shale, like bed 31 6.0
32. Limestone, light to dark gray, some beds brown, consisting of small pellets, medium-bedded; one bed filled with crinoid remains, unit contains ammonoids (*Pseudosageceras multilobatum*, *Subvishnuites* sp. indet., *Stacheites* sp. indet.), pelecypods, and orthocerids 5.0
31. Shale, gray-black, with 1–4 inch beds of fine, sandy, dark limestone that weathers brown 11.0
30. Limestone, light to dark gray, fine-grained, very glauconitic in part, medium-bedded; contains ammonites (*Arctomeekoceras* sp. indet.,

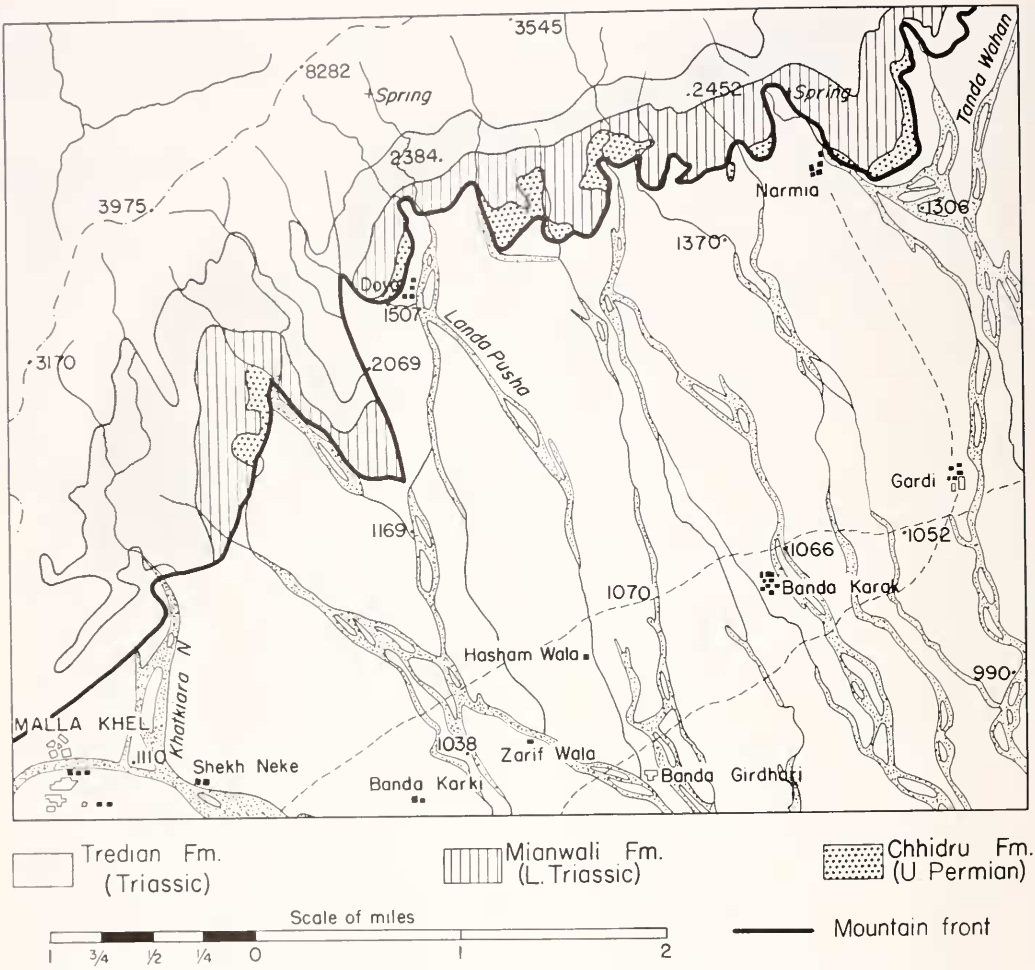

Figure 20. Locality map of Narmia and Landa region, Surghar Range, West Pakistan, showing distribution of late Permian and Triassic formations. Geologic data from unpublished map by W. Danilchik and A. Shah.

Prohungarites cf. *crasseplicatus*, *Anakashmirites* sp. indet., *Subvishnuites* sp. indet., *Xenoceltites* sp. indet., *Procarnites kokeni*, *Nordophiceras* cf. *planorbis*, *Dagnoceras* cf. *zappanense*) and pelecypods — 10.0

29. Shale, olive-gray, with 10 inch bed of cross-bedded, tan, fine-grained, micaceous sandstone near top — 9.0
28. Limestone, dark gray, fine-grained, very hard — 6.0
27. Limestone, brown, very hard, weathers purple-brown, made up of shell fragments — 1.5
26. Limestone, dark gray, weathers iron brown, and some sandstone beds; contains poorly preserved ammonites and pelecypods — 2.0

Total 140.5

Mittiwali Member

25. Shale and sandstone like bed 22 — 2.0
24. Sandstone like bed 21 — 2.0
23. Shale, black, alternating with gray sandstone in beds 1–3 inches thick — 2.5
22. Sandstone, dark gray, fine- to medium-grained, massive, cross-bedded — 5.0
21. Shale, black and olive gray, with intermittent beds of tan, cross-bedded sandstone like bed 20 — 70.0
20. Sandstone, grayish tan, cross-

bedded, in beds 2–18 inches thick, individual sand beds separated by olive shale beds 1–8 inches thick	4.0
19. Shale, olive gray, few thin beds of fine-grained, laminated sandstone	30.0
18. Limestone, gray, fine-grained, with intermittent 1–12 inch shale beds	9.0
17. Shale, olive, with thin, lenticular beds of argillaceous limestone and calcareous siltstone	15.0
16. Limestone, gray, in beds 1–4 inches thick, region of structural complexity with folds and faults	12.0
15. Siltstone, gray, calcareous, laminated, with intermittent beds of black shale	5.0
14. Limestone, gray, hard, massive, weathers tan; contains *Pseudosageceras*	1.5
13. Shale, like bed 10 but with more beds of siltstone and fine-grained sandstone, beds near top calcareous	90.0
12. Siltstone, gray, shaly in part, with interbeds of 3–6 inch beds of gray limestone and some black shale	8.0
11. Shale, black, with numerous 1–3 inch beds of laminated tan siltstone; some structural complexities in this area, thickness approximate	220.0
beds 2–4 inches thick, with a few thin shale interbeds	1.0
9. Shale, tan and gray, silty	0.2
8. Limestone, gray, argillaceous, massive, weathers tan; contains poorly preserved ammonites	1.0
7. Limestone, gray, fine-grained, weathers tan, with some thin beds of black, silty shale; contains poorly preserved ammonites	6.8
6. Limestone, gray, like bed 5, *Gyronites* common	1.5
5. Limestone, gray, medium-bedded; contains ammonites (*Gyronites*)	1.0
Total 487.5	
Kathwai Member	
4. Limestone, gray, hard, massive, glauconitic, no fossils seen	1.3
3. Limestone, gray, speckled brown, glauconitic	0.7
2. Dolomite, grayish tan, fine-grained, coquinoidal, consisting mainly of echinoderm fragments; uppermost foot contains glauconite	5.0
1. Limestone, grayish tan, coquinoidal, partly dolomitized; contains Permian-type brachiopods	0.5
Total 7.5	
Total Mianwali Formation 635.5	

Figure 21. Triassic formations in Narmia Nala, Surghar Range, West Pakistan. The strata up through the first prominent limestone bed in the middle of the photograph are the upper part of the Mittiwali Member and the Narmia Member of the Mianwali Formation. The overlying thin bedded strata are the Landa Member of the Tredian Formation, and the overlying massive sandstone beds are the Khatkiara Member.

CHHIDRU FORMATION (Upper Permian)	
00. Sandstone, white, fine-grained	0.9
0. Limestone, light gray, detrital, sandy; contains productids, *Bellerophon*, and other typical Permian forms	

Stratigraphic section of part of the Triassic formations exposed in Landa Nala, Surghar Range, West Pakistan (Fig. 20).

Bed No.	Thickness Feet
TREDIAN FORMATION (?Lower and ?Middle Triassic)	
Khatkiara Member	
20. Sandstone, white, massive	
Landa Member	

19. Shale and sandstone like bed 18 but more sandstone and these in thicker beds with frequent shale breaks, sandstone pink to red on weathered surface, contains ripple marks and plant fragments	27.0
18. Shale, black, with much micaceous, tan to gray to pink siltstone and sandstone in beds 1–24 inches thick	70.0
Total 97.0	

MIANWALI FORMATION

Narmia Member

17. Limestone, gray, made up entirely of pissolites; contains *Spiriferina* and echinoid spines	4.5
16. Limestone, gray-brown, typical of sequence, with beds of thin-bedded sandstone, a few one foot shale beds, vague suggestion of pelecypods present	15.0
15. Sandstone, olive, fine-grained, micaceous, laminated	2.0
14. Shale, black with much micaceous siltstone and frequent beds of brown weathering, cross-bedded, calcareous sandstone and argillaceous limestone	29.0
13. Limestone, gray, weathers brown, with few thin shale beds, no fossils seen	3.0
12. Shale, gray, black, with thin beds of gray laminated siltstone and gray limestone, no fossils seen	21.0
11. Limestone, gray, contains poorly preserved ammonites	1.5
10. Shale, black, with some thin beds of gray, laminated siltstone	4.5
9. Limestone, gray, glauconitic, very hard; contains a few ammonites (*Pseudosageceras multilobatum*, *Anakashmirites* sp. indet., *Nordophiceras* cf. *planorbis*), orthocerids, and rhynchonellid brachiopods	7.0
8. Shale, olive, with thin beds of laminated siltstone	5.0
7. Limestone, light gray, very hard, contains poorly preserved ammonites (*Subvishnuites* sp. indet.) and pelecypods	6.0
6. Shale, black, silty in part, micaceous, with 1–3 inch beds of sandy limestone and gray calcareous sandstone	5.3
5. Limestone, light gray, fine-grained, glauconitic, medium-bedded; contains poorly preserved ammonites (*Pseudosageceras multilobatum*, *Arctomeekoceras* sp. indet., *Subvishnuites* sp. indet.)	3.5
4. Shale, black, with some thin beds of light gray, sandy limestone	1.8
3. Limestone like bed 1	5.0
2. Shale, black, with some thin beds of light gray, calcareous, fine-grained sandstone	7.0
1. Limestone, gray, with brown irregular portions, fine-grained, sandy in part, with some thin beds of calcareous sandstone; contains poorly preserved pelecypods and brachiopods. This unit is believed to be equivalent to the Bivalve beds of the Salt Range	6.5
Total 127.6	

Mittiwali Member

0. Section not measured in detail, first abundant fossils (*Stephanites*) occur in thin limestone beds 135 feet below the base of the Narmia Member

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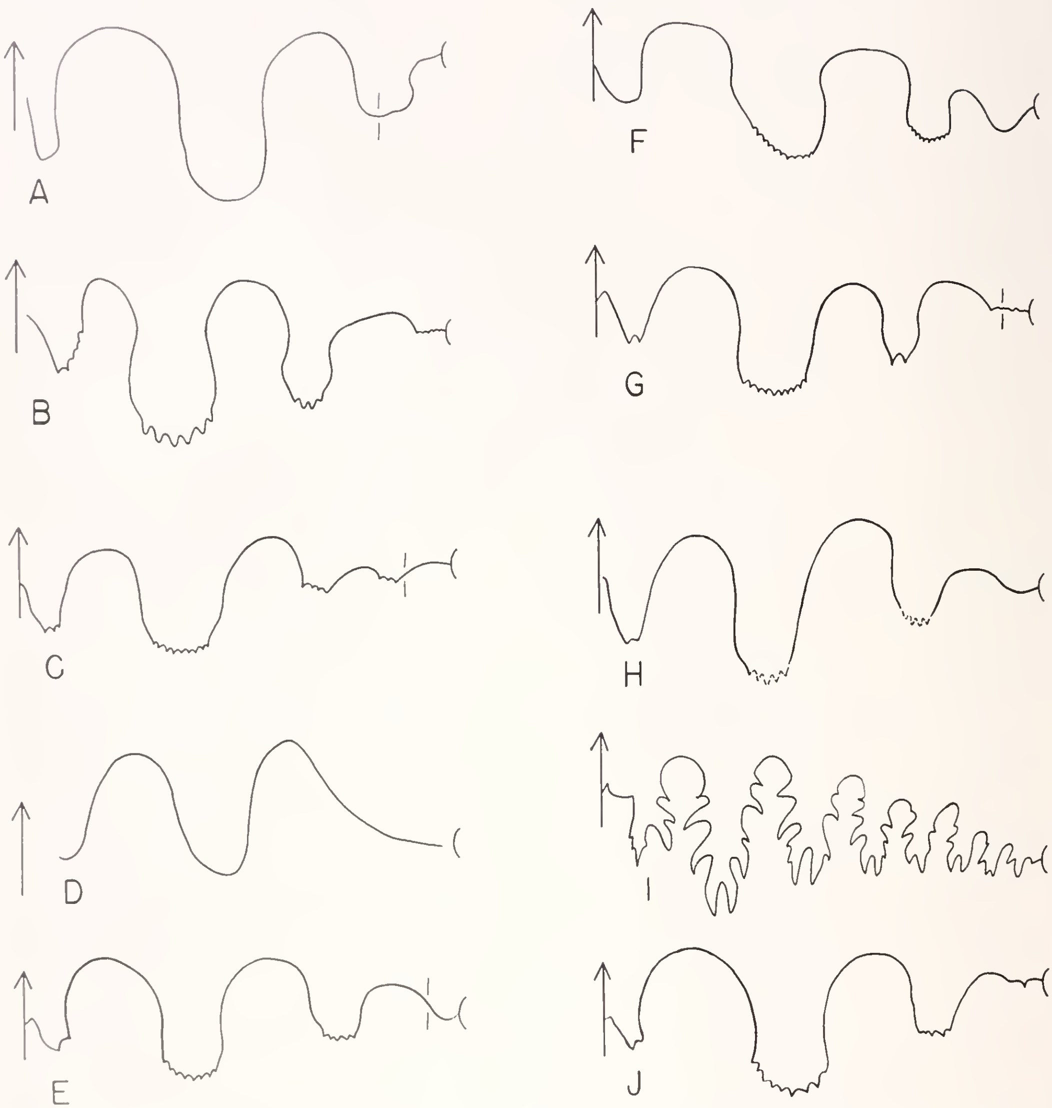

Figure 22. Diagrammatic representation of the suture of ammonites from the Narmia Member of the Mianwali Formation, Surghar Range and Salt Range, West Pakistan. A, *Dagnoceras* cf. *zappanense* Arthaber at a whorl height of 6.5 mm, MCZ 9565; B, *Nordophiceras* cf. *planorbis* (Waagen) at a whorl height of 11 mm, MCZ 9614; C, *Prohungarites* cf. *crasseplicatus* (Welter) at a whorl height of 13 mm, MCZ 9606; D, *Stacheites* sp. indet., at a whorl height of 6 mm, MCZ 9609; E, *Arctomeekoceras* sp. indet., at a whorl height of 9 mm, MCZ 9585; F, *Anakashmirites* sp. indet., at a whorl height of 9 mm, MCZ 9603; G, *Svalbardiceras* sp. indet., at a whorl height of 11.5 mm, MCZ 9587; H, *Xenoceltites sinuatus* (Waagen) at a whorl height of 15.5 mm, topotype MCZ 9581; I, *Procornites kokeni* (Arthaber) at a whorl height of 14 mm, MCZ 9595; J, *Subvishnuites* sp. indet., at a whorl height of 7 mm, MCZ 9599.

PLATE 1. XENOCELTITES and PSEUDOSAGECERAS

Figures		Page
1, 2.	*Xenoceltites sinuatus* (Waagen). Holotype, from sandstone bed of Narmia Member just above hard "Bivalve limestone," east side of Chhidru Nala, Salt Range, West Pakistan. GSI 7110. X1	389
3, 4.	*Xenoceltites sinuatus* (Waagen). Topotype, from sandstone bed of Narmia Member (bed no. 23) just above hard "Bivalve limestone," east side of Chhidru Nala, Salt Range, West Pakistan. MCZ 9581. X1	389
5, 6.	*Xenoceltites sinuatus* (Waagen). Syntype of *Lecanites laqueus* Waagen (1895, pl. 38, figs. 9a, b) from "Bivalve layers" east side of Chhidru Nala, Salt Range, West Pakistan. GSI 7221. X1.5	389
7, 8.	*Xenoceltites sinuatus* (Waagen). Syntype of *Lecanites laqueus* Waagen (1895, pl. 38, fig. 10) from "Bivalve layers" east side of Chhidru Nala, Salt Range. West Pakistan. GSI 7222. X1	389
9, 10.	*Xenoceltites* sp. indet. From 10 foot bed of limestone 17 feet above the base of Narmia Member (bed no. 30), Narmia Nala, Surghar Range, West Pakistan. MCZ 9583. X1	390
11, 12.	*Pseudosageceras multilobatum* Noetling. From 5 foot bed of limestone 38 feet above base of Narmia Member (bed no. 32), Narmia Nala, Surghar Range, West Pakistan. MCZ 9578. X1.5	388

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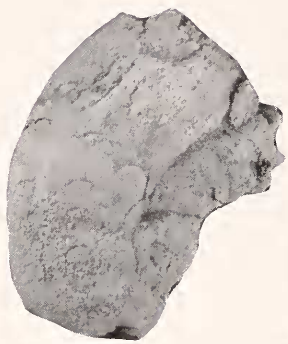

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PLATE 2. ARCTOMEEKOCERAS, SVALBARDICERAS, and PROCARNITES

Figures		Page
1, 2.	*Arctomeekoceras* sp. indet. From 3.5 foot bed of limestone 20 feet above base of Narmia Member (bed no. 5), Landa Nala, Surghar Range, West Pakistan. MCZ 9584. X1	398
3, 4.	*Arctomeekoceras* sp. indet. From 10 foot bed of limestone 17 feet above base of Narmia Member (bed no. 30), Narmia Nala, Surghar Range, West Pakistan. MCZ 9585. X2	398
5.	*Arctomeekoceras* sp. indet. From 10 foot bed of limestone 17 feet above Narmia Member (bed no. 30), Narmia Nala, Surghar Range, West Pakistan. MCZ 9586. X1.5	398
6–9.	*Svalbardiceras* sp. indet. 6, 7, outer whorls of phragmocone, X1.5; 8, 9, inner whorls, X4. From 8 foot bed of limestone 126 feet above base of Narmia Member (bed no. 34), Nammal Gorge, Salt Range, West Pakistan. MCZ 9587.	394
10, 11.	*Procarnites kokeni* (Arthaber). From 10 foot bed of limestone 17 feet above base of Narmia Member (bed no. 30), Narmia Nala, Surghar Range, West Pakistan. MCZ 9593. X2	390
12, 13.	*Procarnites kokeni* (Arthaber). From 10 foot bed of limestone 17 feet above base of Narmia Member (bed no. 30), Narmia Nala, Surghar Range, West Pakistan. MCZ 9594. X1.5	390

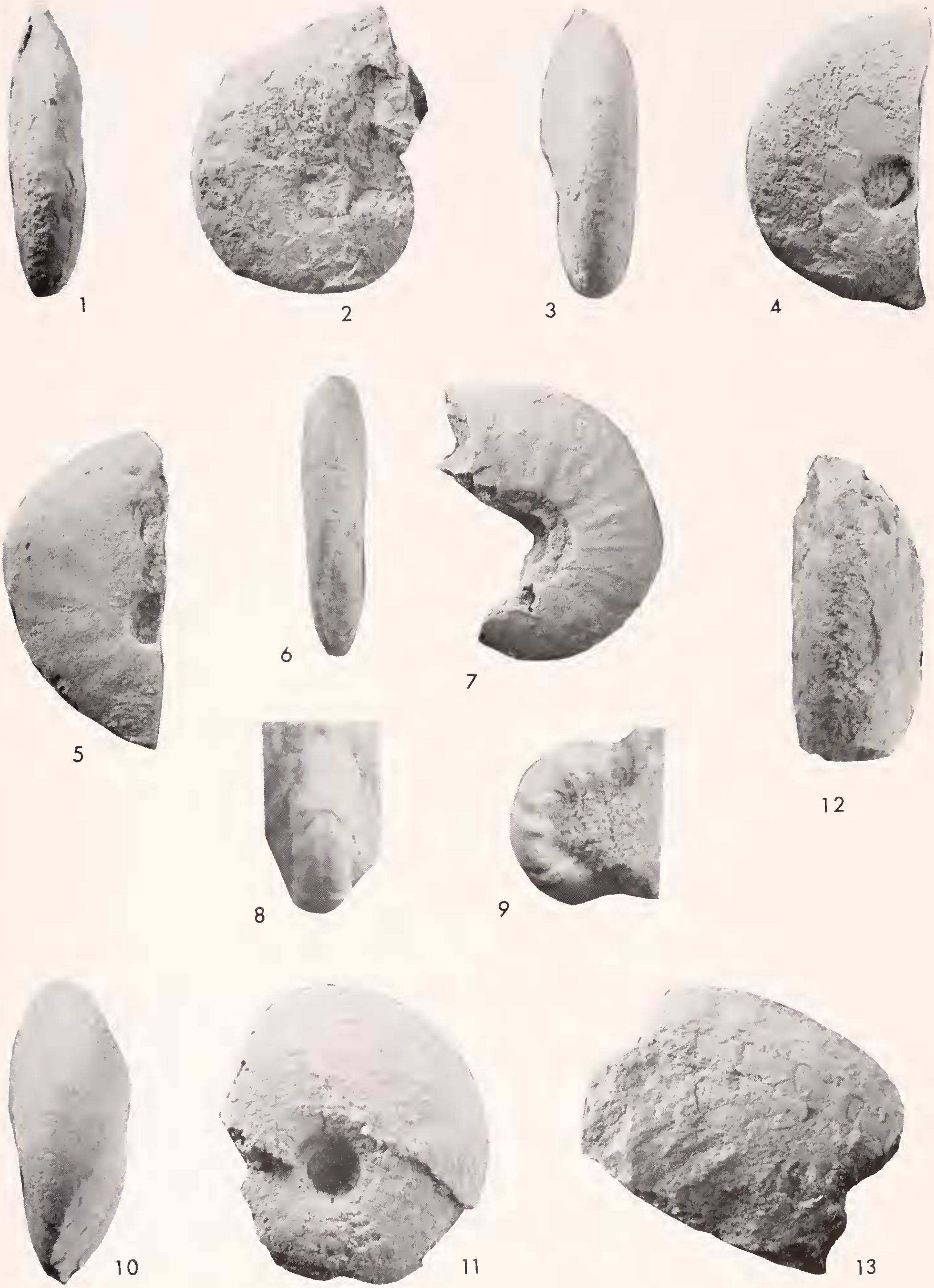
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PLATE 3. SUBVISHNUITES, ANAKASHMIRITES, DAGNOCERAS, PROHUNGARITES, and STACHEITES

Figures		Page
1.	*Subvishnuites* sp. indet. From a 5 foot bed of limestone, 27 feet above base of Narmia Member (bed no. 32), Narmia Nala, Surghar Range, West Pakistan. MCZ 9596. X1	388
2, 3.	*Subvishnuites* sp. indet. From a 5 foot bed of limestone, 27 feet above base of Narmia Member (bed no. 32), Narmia Nala, Surghar Range, West Pakistan. MCZ 9597. X1.5	388
4, 5.	*Subvishnuites* sp. indet. From a 2 foot bed of limestone, 76 feet above the base of the Narmia Member (bed no. 36), Narmia Nala, Surghar Range, West Pakistan. MCZ 9598. X1.5	388
6, 7.	*Anakashmirites* sp. indet. From a 7 foot bed of limestone, 40 feet above base of Narmia Member (bed no. 9), Landa Nala, Surghar Range, West Pakistan. MCZ 9603. X2	393
8.	*Anakashmirites* sp. indet. From a 10 foot bed of limestone, 17 feet above base of Narmia Member (bed no. 30), Narmia Nala, Surghar Range, West Pakistan. MCZ 9604. X1.5	393
9, 10.	*Dagnoceras* cf. *zappanense* Arthaber. From a 10 foot bed of limestone, 17 feet above base of Narmia Member (bed no. 30), Narmia Nala, Surghar Range, West Pakistan. MCZ 9605. X2	396
11, 12.	*Prohungarites* cf. *crasseplicatus* (Welter). From 10 foot bed of limestone, 17 feet above base of Narmia Member (bed no. 30), Narmia Nala, Surghar Range, West Pakistan. MCZ 9606. X1.5	400
13.	*Stacheites* sp. indet. From a 5 foot bed of limestone, 38 feet above base of Narmia Member (bed no. 32), Narmia Nala, Surghar Range, West Pakistan. MCZ 9609. X2	396

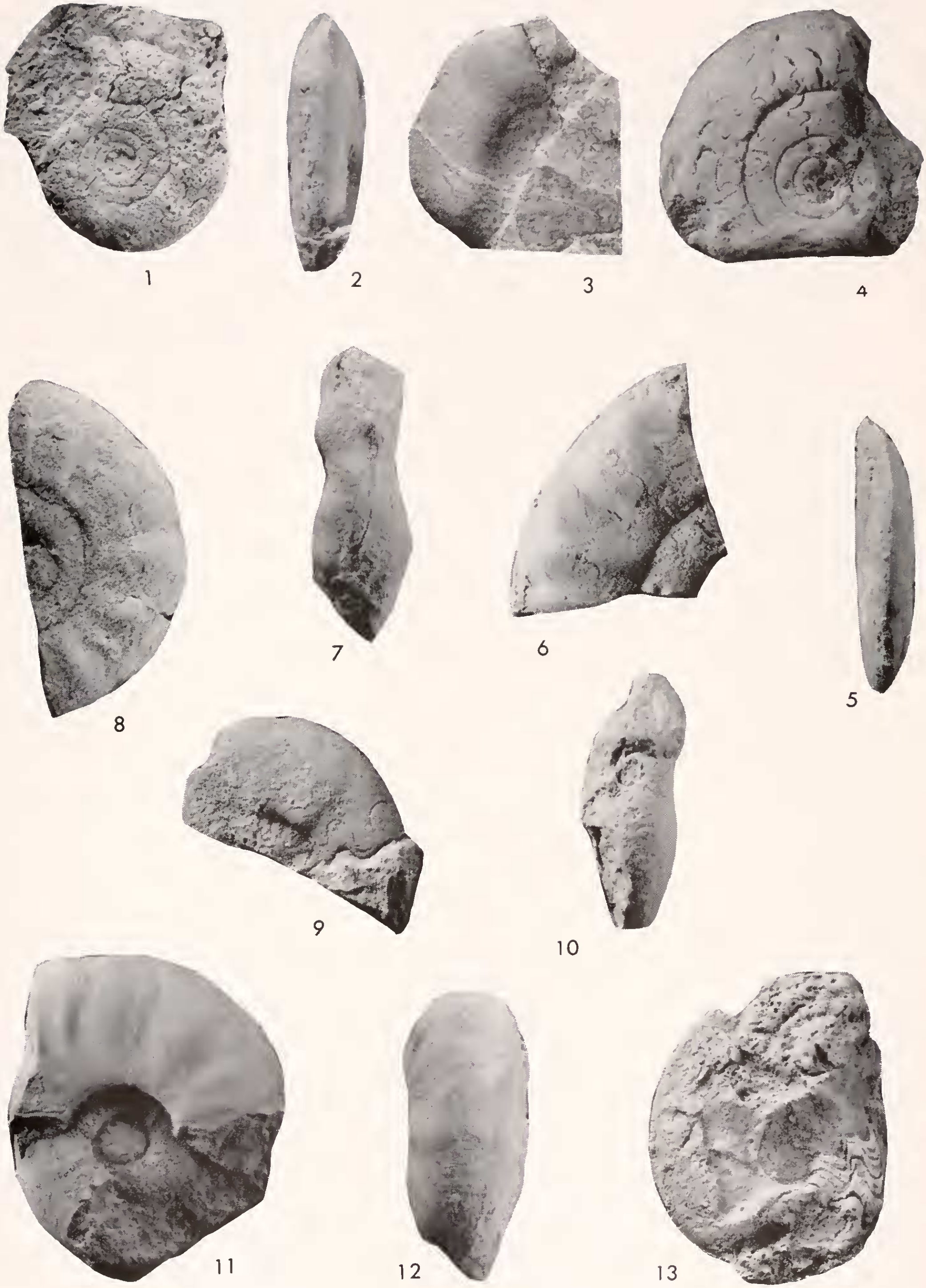
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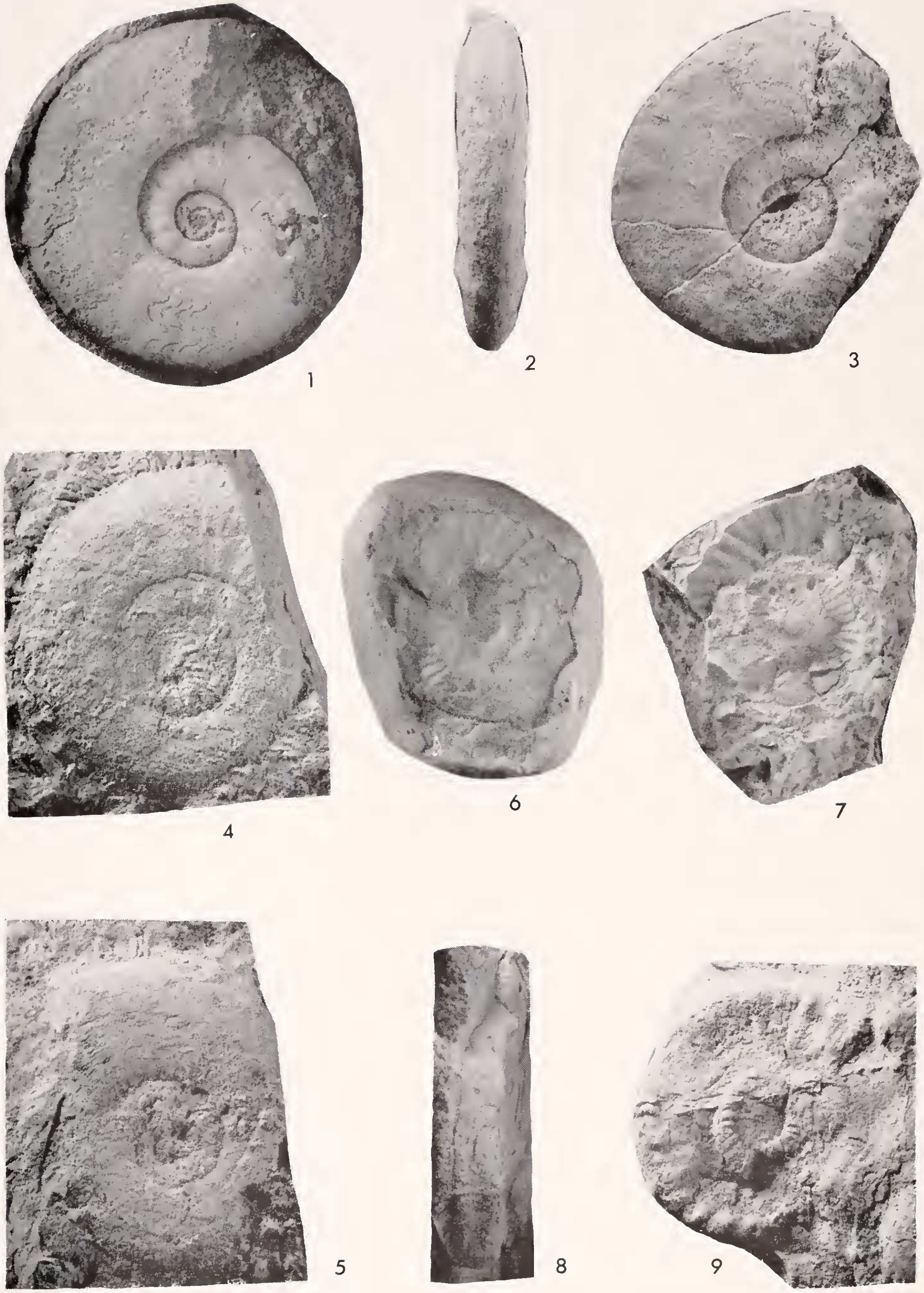
PLATE 4. NORDOPHICERAS, PSEUDHARPOCERAS, and TIROLITES

Figures		Page
1.	*Nordophiceras planorbis* (Waagen). Holotype, from sandstone bed of the Narmia Member above the hard "Bivalve limestone" on east side of Chhidru Nala, Salt Range, West Pakistan. GSI 7226. X1	397
2, 3.	*Nordophiceras planorbis* (Waagen). Topotype, from sandstone bed of the Narmia Member above the hard "Bivalve limestone" on east side of Chhidru Nala, Salt Range, West Pakistan. MCZ 9611. X1	397
4.	*Nordophiceras* cf. *planorbis* (Waagen). From 10 foot bed of limestone, 17 feet above base of Narmia Member (bed no. 30), Narmia Nala, Surghar Range, West Pakistan. MCZ 9613. X1.5	398
5.	*Nordophiceras* cf. *planorbis* (Waagen). From 7 foot bed of limestone, 40 feet above base of Narmia Member (bed no. 9), Landa Nala, Surghar Range, West Pakistan. MCZ 9614. X1.5	398
6, 7.	*Pseudharpoceras spiniger* Waagen. Holotype, Fig. 6, plaster cast, Fig. 7, mould, locality and horizon not known with certainty, presumably from Topmost Limestone, Sheik-Budin Hills, Trans-Indus region. West Pakistan. GSI 7134. X1	386
8, 9.	*Tirolites* sp. indet. From micaceous sandstone bed 17 feet above base of Narmia Member (bed no. 29), Nammal Gorge, Salt Range, West Pakistan. MCZ 9615. X1	400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